Triangle Regional Report

SMARTlink

Getting You There Safely

North Carolina Statewide Intelligent Transportation System Strategic Deployment Plan

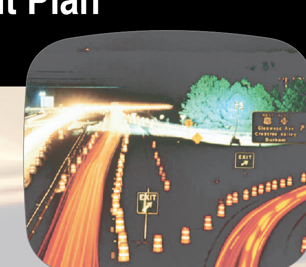

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Table of Contents

List of Figures

List of Tables

List of Abbreviations/Acronyms[1]

APTS	*Advanced Public Transportation Systems*. FTA program to focus R&D and funding efforts on ITS technologies composed of five main areas: vehicle operations and communication, high occupancy vehicles, customer interface, rural transportation, and market segment development.
ARTS	*Advanced Rural Transportation Systems.*
ATIS	*Advanced Traveler Information Systems*. Vehicle features that assist the driver with planning, perception, analysis, and decision-making.
ATMS	*Advanced Traffic Management Systems*. An array of institutional, human, hardware, and software components designed to monitor, control, and manage traffic on streets and highways.
AVL	*Automatic Vehicle Location*. The installation of devices on a fleet of vehicles (e.g. buses, trucks, or taxis) that enable the fleet manager to determine the location of specific, AVL-equipped vehicles in the road network.
CARAT	*Congestion Avoidance and Reduction for Automobiles and Trucks*. ATIS/ATMS system in Charlotte, NC involving an advanced transportation management center (TMC) and a subscription-based advanced traveler information system (ATIS) that will provide incident location and response as well as consumer information to its users. This is the original acronym/name for the system and has been replaced with the name “Metrolina Regional Transportation Management System”.
CBD	*Central Business District*.
CCTV	*Closed Circuit Television*.
Clearinghouse	A clearinghouse stores real-time data for traveler information. The system will include data from system loops, intersections, a detector station, posted incident reports, IMAP incident reports, and real-time bus schedule information. All information whether it is stored locally or remotely, will be accessible from a central location.
CVO	*Commercial Vehicle Operations*. The application of ITS technology to commercial vehicles.
CVISN	*Commercial Vehicle Information Systems and Networks.* Refers to the ITS information system elements that support CVO.

[1] A number of the definitions regarding communications devices and protocols are from, “Newton’s Telecom Dictionary,” 16th Edition, Harry Newton, Telecom Books, February 2000.

DMS	*Dynamic Message Signs*.
DMV	*Department of Motor Vehicles*.
DSL	*Digital Subscriber Line*. A generic term for a family of digital lines that provide high-speed data transfer rates across standard telephone lines. Typical bit rates on a DSL connection range from 128kbs to 8Mbs.
FHWA	*Federal Highway Administration*.
HAR	*Highway Advisory Radio*. The transmission of localized traffic advisory messages using 520 AM and 1610 AM frequencies.
HOV	*High Occupancy Vehicle*. Any vehicle containing more than one person.
IMAP	*Incident Management Assistance Patrol.* A service run by the NCDOT to identify freeway incidents and assist emergency personnel.
Incident	Any accident, stalled vehicle, or other delay-causing problem on a street or freeway.
ISDN	*Integrated Services Digital Network*. Leased-line data network over telephone lines. A typical ISDN line connects at 128kbs but is more costly in both the end equipment and monthly cost.
ISP	*Information Service Provider.*
ISTEA	*Intermodal Surface Transportation Efficiency Act*, passed by Congress and approved by the President in December of 1991, becoming Public Law 102-240.
Kbs	*Kilobytes per second*.
Kiosk	An interactive information center for traffic or travel data located in shopping malls, parking decks, hotels, airports, businesses, transit terminals, etc. It always has interactive computer capability and sometimes has communications linkage to real-time traffic data.
Market packages	The FHWA has identified 56 market packages that describe projects in general terms and identifies the information that must be shared between the various components.
Mbs/Mbps	*Megabits per second*.
MDT	*Mobile Dispatch Technology*.
MPO	*Metropolitan Planning Organization*.
MRTMC	*Metrolina Regional Transportation Management Center*

Multimodal	The use or ability to use multiple modes of transportation; i.e., automobiles and buses.
Multiplexers	Electronic equipment that allows two or more signals to pass over one communications circuit.
NIA	*National ITS Architecture.* The NIA is a framework that describes what a system does and how it does it. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components.
PART	*Piedmont Authority on Regional Transportation.* Regional Transportation between Winston-Salem, Greensboro, and the regional hub at Greensboro Regional Airport.
RSVP	*Ride Sharing Vehicle Program*.
RWIS	*Roadway Weather Information System.*
Smart Card Technology	A regional electronic payment system that permits the same method of payment for all transit systems in the region. In addition to permitting travelers to use multiple bus systems without a complicated payment system, Smart Cards enable the various transit and planning agencies to better track ridership, transfers, and other information that can be used to plan for future transit enhancements.
T-1	A digital transmission link with a total signaling speed of 1.544 Mbps.
TAC	*Transportation Advisory Committee*.
TCC	*Traffic Control Center*. Sometimes used interchangeably with Traffic Operations Center (TOC). Strictly defined, TCCs primarily control traffic while TOCs are headquarters for enforcement, operations, and maintenance personnel. TCCs and TOCs often are combined functionally.
TCC	*Technical Coordinating Committee*.
TEA-21	*Transportation Equity Act for the 21st Century*
TMC	*Transportation Management Center*.
TMS	*Transportation Management System.*
Traffic Signal Systems	A system of interconnected traffic signals (signal controllers) whose major objective is to support continuous movement and minimized delay along an arterial or a network of arterials.
TRTMC	*Triangle Regional Transportation Management Center*

TTA	*Triangle Transit Authority*.
User Packages	A list of 63 technology groups that define ITS elements and projects. Where a Market Package defines a general goal of ITS, User Packages define the technologies and deployments that compromise the Market Package.
VRAS	*Voice Remote Access System*.
VMT	*Vehicle Miles Traveled*
WIM	*Weigh-In-Motion*.

Executive Summary

The North Carolina Department of Transportation (NCDOT) is developing a Statewide Intelligent Transportation Systems (ITS) Strategic Deployment plan. The purpose of this plan is to develop a structured implementation of ITS projects by addressing the immediate and long-term transportation needs of the state.

Developing any statewide plan requires input from many sources, not just from a statewide board or agency. The statewide plan, therefore, is the result of several regional plans, developed through an aggressive stakeholder outreach program that invited the input from well over 1,500 people of different backgrounds. This document represents responses to the statewide plan from the stakeholders in the Triangle Region.

The process that was used throughout the development of the regional and statewide ITS deployment plans follows the requirements and direction of the National ITS Architecture (NIA), a framework that describes ITS components by their functionality and defines how these components are to work together as a system. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the systems, subsystems, and individual elements.

The Triangle Region encompasses Wake, Durham, and Orange Counties as well as part of Johnston County. The major cities in this region are Raleigh, Cary, Garner, Apex, Wake Forest, Durham, Chapel Hill, Carrboro, and Clayton. Although ITS is relatively new, there are many ITS deployments that are either fully functional, in construction, or in the planning stages throughout the Triangle Region.

From the stakeholder input process, the ITS Strategic Deployment Plan process identified 65 transportation needs. These needs were ranked by the regional transportation leaders to identify the most pressing issues, which in turn, permitted the use of the NIA to develop a regional ITS deployment plan and architecture that addressed these needs.

From this process, it was determined that traffic control, public transportation management, archived data function, and pre-trip travel information were the most urgent issues. Short- and long-term project plans were then determined from the needs. The key component of the Triangle Region ITS Deployment plan is the development of a central database of traveler information to be disseminated to motorists throughout the region.

The concept of the Triangle Regional architecture is that NCDOT Traffic Management Center controls most of the traffic operations equipment through the region, and, therefore, has easy access to most of the generated traffic information. External inputs, such as from the City of Raleigh signal system, the Incident Management Assistance Patrol (IMAP) program and traffic information from the other traffic operations centers needs to be accessed, but not generated or stored locally. The concept of the architecture is that the NCDOT will share information both regionally and statewide to provide information that can be easily accessed from one concise front end.

The regional communications architecture is complex because of the deployments (both existing and planned) and the amount of ITS already present in the region. The system will encompass the existing communications between NCDOT; the cities of Raleigh, Durham, and other municipalities in the area; and the existing ITS elements, with new deployments providing or improving communication, as necessary.

Introduction

ITS are applications of advanced traffic operations and communications technologies used to improve safety, relieve congestion, and provide better information to travelers. The NCDOT has determined that a blueprint is needed to guide future deployment of ITS throughout the state. This guided deployment of ITS will result in an integrated, cost-effective plan that will increase motorist safety and security, preserve infrastructure and services, ensure transportation system efficiency, provide information, and increase economic development opportunities throughout North Carolina.

The statewide ITS Strategic Deployment plan will consist of a compilation of statewide needs and the needs gathered in nine Regional ITS Strategic Deployment Plans. This Triangle Regional ITS Deployment plan represents one of those nine regional reports. To guide the future deployment of ITS technology in the state, NCDOT is developing a statewide ITS Strategic Deployment plan. This planning process has developed a structured implementation of ITS projects by addressing the immediate and long-term transportation needs in the state. The Department is committed to improving the safety and efficiency of North Carolina’s transportation systems, including transit, rail, aviation, bicycle, and pedestrian, as well as highways.

Developing a statewide plan of any sort requires input from a broad base of stakeholders across the board, not just from a statewide board or agency. The statewide plan, therefore, will be the result of three rural and six urban regional plans. Each of these independent but coordinated plans has been developed through an aggressive stakeholder outreach program that invited input from approximately 1,500 people from different backgrounds who have important influence over or opinion on North Carolina’s transportation system. This deployment plan takes into account the issues of previously developed area-wide plans as well as multi-modal plans from local agencies.

The Triangle Regional ITS Plan is intended to be a living document that represents a consensus of ideas and concerns from municipalities and other entities in this region, the Division and other NCDOT representatives, and from a diverse group of stakeholders in the North Carolina transportation system.

Introduction to ITS

Increasing the capacity of the transportation network has traditionally been the responsibility of transportation planners, highway designers, and road builders. When a roadway neared capacity, the most frequent response by the NCDOT and other public agencies was to add additional lane miles. Today, as development increases, it is becoming increasingly difficult to add additional lanes without expensive right-of-way acquisitions. ITS has evolved over the last decade to describe a federal emphasis area for transportation systems. ITS also denotes a body of knowledge and discipline area among transportation systems, vehicle systems, and communication systems engineers. The federal program was first authorized by the 1991 Intermodal Surface Transportation Act (ISTEA) and continued by the 1998 Transportation Equity Act for the 21st Century (TEA-21).

The program is supported by all modal administrations within the United States Department of Transportation (USDOT), and by a broad-based professional association called ITS America, which acts as an official advisor on the ITS program to the USDOT and the various administrations of that department and other entities. The National Program Plan for ITS identified the following goals for the national program:

1. Widespread implementation of ITS to enhance the capacity, efficiency, and safety of the federal-aid highway system; to serve as an alternative to additional capacity of the federal-aid highway system; and to enhance development of intermodal connectivity.
2. Enhance, through the more efficient use of the federal-aid highway system, the efforts of several states to attain air quality goals established pursuant to the Clean Air Act.
3. Enhance the safe and efficient operation of the nation's highway system, particularly system aspects that will increase safety. Identify system aspects that may reduce safety.
4. Develop and promote ITS and the ITS industry in the United States.
5. Reduce social, economic, and environmental costs associated with traffic congestion.
6. Enhance U.S. industrial and economic competitiveness and productivity.
7. Develop a technology base for intelligent vehicle-highway systems and establish the capability to perform demonstration experiments, using existing national laboratory capabilities, where appropriate.
8. Facilitate the transfer of transportation technology from national laboratories to the private sector.

ITS, in short, is the use of advanced traffic operations technologies and communication technologies that help increase throughput on existing facilities, improve safety, and provide better and more accurate traveler information to the public.

Additional throughput occurs in many ways. Advanced traffic surveillance and signal control systems, for instance, have resulted in travel time improvements ranging from 8 to 25%. Incident management programs can reduce delay associated with congestion caused by incidents by as much as 45% and freight mobility systems have shown productivity gains of more than 25% per truck per day.

The following two examples illustrate the beginnings of ITS programs in North Carolina. At the rest areas associated with some of the welcome centers on interstate highways entering the state, traveler information kiosks promote tourist attractions, highway safety messages, highway construction zones, highway services, hotels, restaurants, etc.

These interactive traveler information kiosks provide printed directions to destinations and have the capability of downloading html files that could convey weather information, real-time traffic conditions, incidents, etc. They are a basic, in-place building block for an Advanced Traveler Information Systems (ATIS) in this region. The same type of facility exists at several welcome centers in North Carolina and Tennessee. This private-sector partnership with the state is an excellent example of how ITS is already deployed, and is extremely popular with the tourism industry in the state.

The second example of an in-place component that relates to the ITS program is a freeway assistance service operated by the NCDOT along various portions of I-40 and I-85 in North Carolina. These service patrols (part of the statewide IMAP service that exists in various districts of the NCDOT) provide emergency services such as gasoline, emergency starts, communications, etc. for stranded motorists. They also help to direct traffic around incidents. NCDOT trucks are equipped with communications equipment that could make them effective “vehicle probes” that provide traffic condition information to an information clearinghouse or to one or more of the regional Transportation Management Centers (TMC) in the Triangle, the Triad, or Charlotte.

Introduction to the ITS Strategic Planning Process

The process that is used throughout the development of the regional and statewide ITS deployment plans follows the requirements and direction of the NIA. The NIA is a framework that describes what ITS elements and systems do and how the different elements and control centers function together. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components.

This section describes the process used to develop the deployment plan in the Triangle Region. A more detailed description of the process, and the elements that make up the process used in the plan development, is provided in the Appendix.

ITS Planning Process

The general ITS planning process is shown in **Figure 1**. This methodology is described in detail in "Integrating Intelligent Transportation Systems within the Transportation Planning Process: An Interim Handbook" (FHWA, January 1998) and in the "Implementation Strategies" volume of the National Architecture. This process follows a direct path towards the development of a deployment plan.

The Regional and Statewide ITS Deployment Plans were developed through a multi-step process that meets the goals and objectives of the NIA. This process invites many stakeholders from multiple agencies to provide input into the planning process. In turn, this input is reduced into general and specific projects that form the overall regional and statewide plans.

It is the intent of the NIA that these regional and statewide plans consist of more than individual projects and technologies. The NIA was developed in response to the deployment of systems that were not compatible with one another by many state and local agencies. In addition, as these systems were being planned, designed, and deployed, neither future expansion nor interagency coordination were considered.

The NIA, therefore, is being used to foster communications between agencies with the goal of developing regional and statewide plans that facilitate interagency communication and coordination, as well as long-range visions that accommodate the future integrated growth of ITS in the Triangle Region.

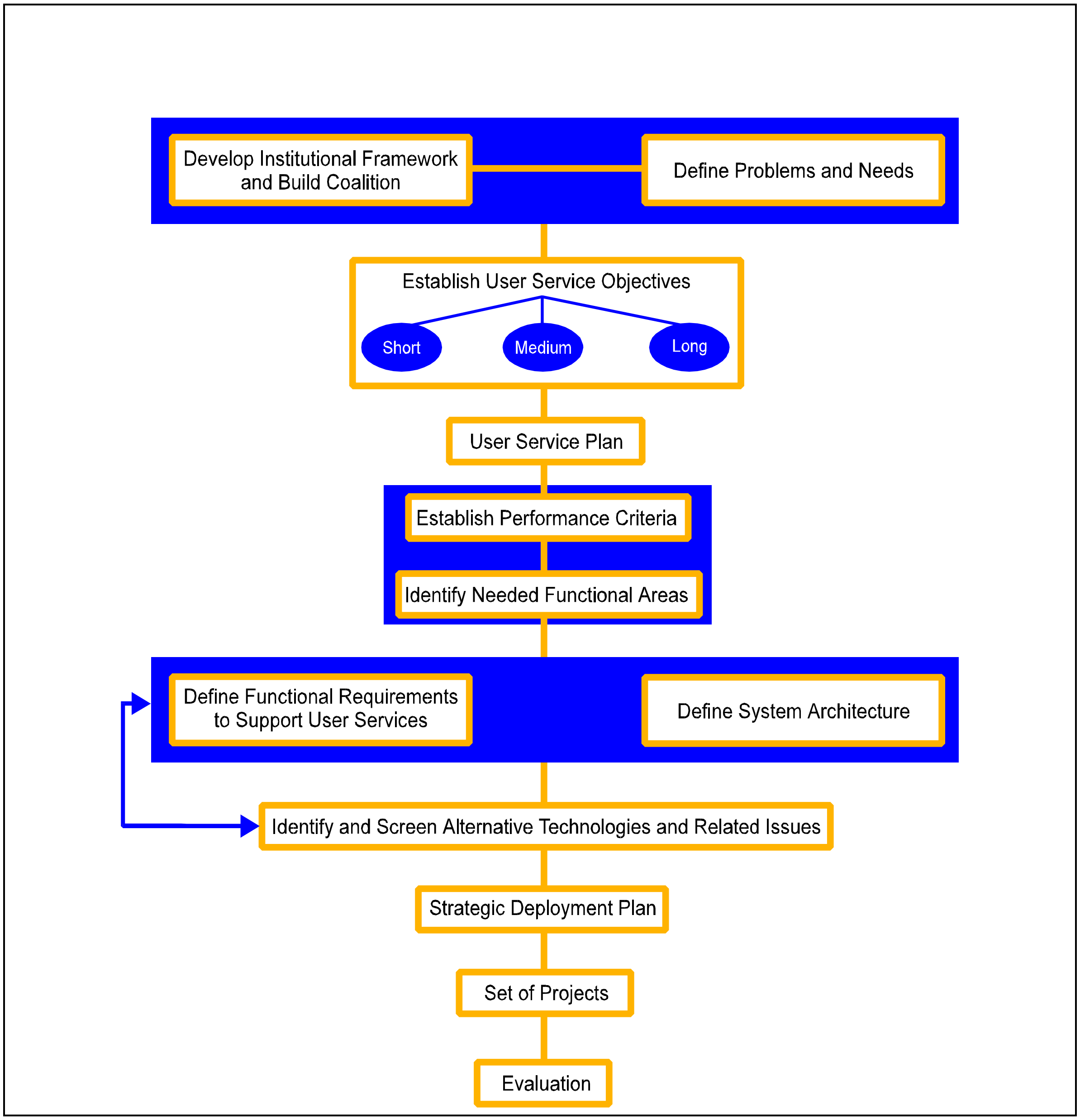


Figure 1. ITS Planning Process.

Background

Project Background

Statewide

The population of North Carolina is growing. As the population grows, so, too, does the demand on the transportation system. This demand is seen throughout the state every day during the peak periods as commute times to and from work continue to increase. Recreational areas are experiencing similar congestion. The projected growth in vehicle miles traveled is shown in **Figure 2**.

The Federal Highway Administration (FHWA) has identified ITS as one of the key responses to congestion mitigation and incident response. ITS is typically more cost-effective than traditional methods of congestion mitigation, such as the addition of new lanes. It also provides tangible side benefits, such as constant data collection for use in planning and operational models.

The NCDOT has identified the need to continue expanding ITS throughout the state. Although there are pockets of deployments (such as traffic signal systems and freeway management systems), these deployments have not been coordinated and do not address all the statewide needs.

The purpose of this document is to demonstrate the need to improve the transportation system, identify ITS solutions, and provide a framework for continued deployment throughout the region and state. This document will be used as part of an overall statewide plan.

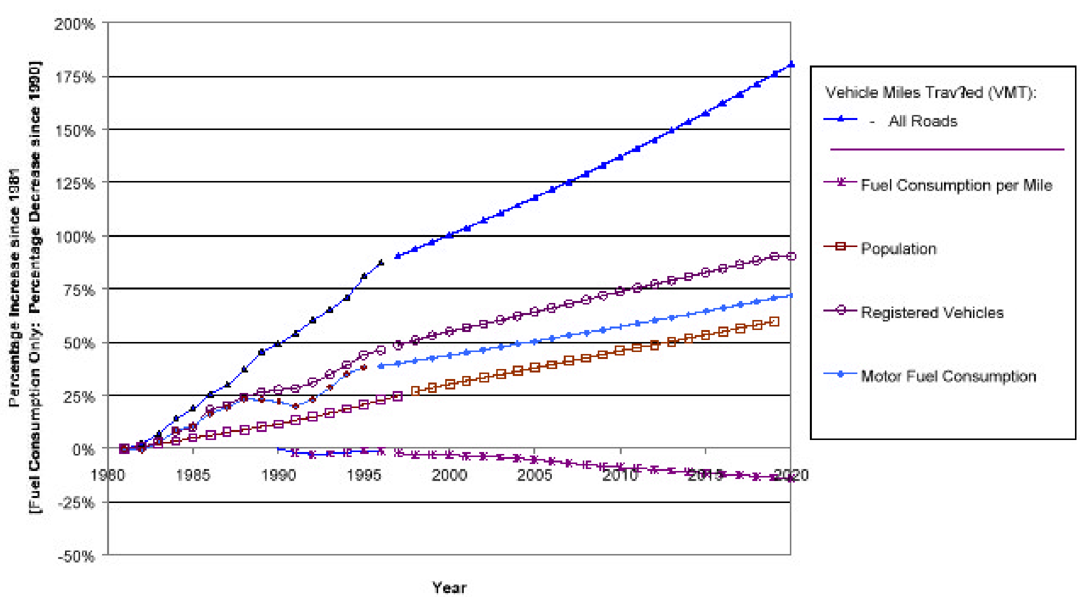


Figure 2. Projection of Key Transportation Indicators for North Carolina.

NCDOT Regional Plans

The North Carolina ITS Strategic Deployment Plan comprises nine regional plans, as shown in **Figure 3** (the I-95 Region is included in the Statewide Report in the interstate system). These regions are grouped according to the ITS needs within each region. For instance, the needs in the Asheville region focus on tourism and weather, while needs in the Interstate region focus on Commercial Vehicle Operations (CVO) and a combination of out-of-state travelers, local commuter travel, and truck routes.

Each of the regions is composed of multiple stakeholders and jurisdictions. These stakeholders include cities, counties, several field divisions within NCDOT, and metropolitan planning organizations (MPOs) for the 17 urban regions in the state. Other interested organizations in urban regions include the police, fire departments, county emergency management agencies, and urban transit agencies.

Through this process, nine regional plans will be developed (the Interstate Region is included as part of the Statewide Plan). All of these plans will be combined to develop a Statewide ITS Deployment Plan that will guide each of the agencies involved as well as NCDOT in the deployment of ITS in the coming years.

Project Goals and Objectives

The Triangle Regional ITS Deployment Strategy must be compatible not only with the regional and local goals set forth by municipalities and counties in the region but also with statewide transportation goals and objectives and the national ITS goals.

Goals of the National ITS Program

The National ITS program was initially created through the ISTEA of 1991, when Congress recognized the critical need to address the aging transportation network. ITS was identified as one of the methods of improving the network.

Since then, the FHWA has been actively pursuing ITS as a key means to improving the safety and efficiency of the transportation system. The National ITS program also has been instrumental in developing the NIA. The NIA is a response to the increased deployment of ITS without clearly defined interoperability between either systems or subsystems.

The program was extended by the ITS Act of 1998, which was a part of TEA-21. This guidance has been effective in the ongoing development and integration of ITS elements.

TEA-21 contained four provisions concerning ITS, which provides funding for the six fiscal years covered by the Act:

- ITS Deployment – small incentive grants to states and local governments to encourage ITS integration and CVO infrastructure deployment

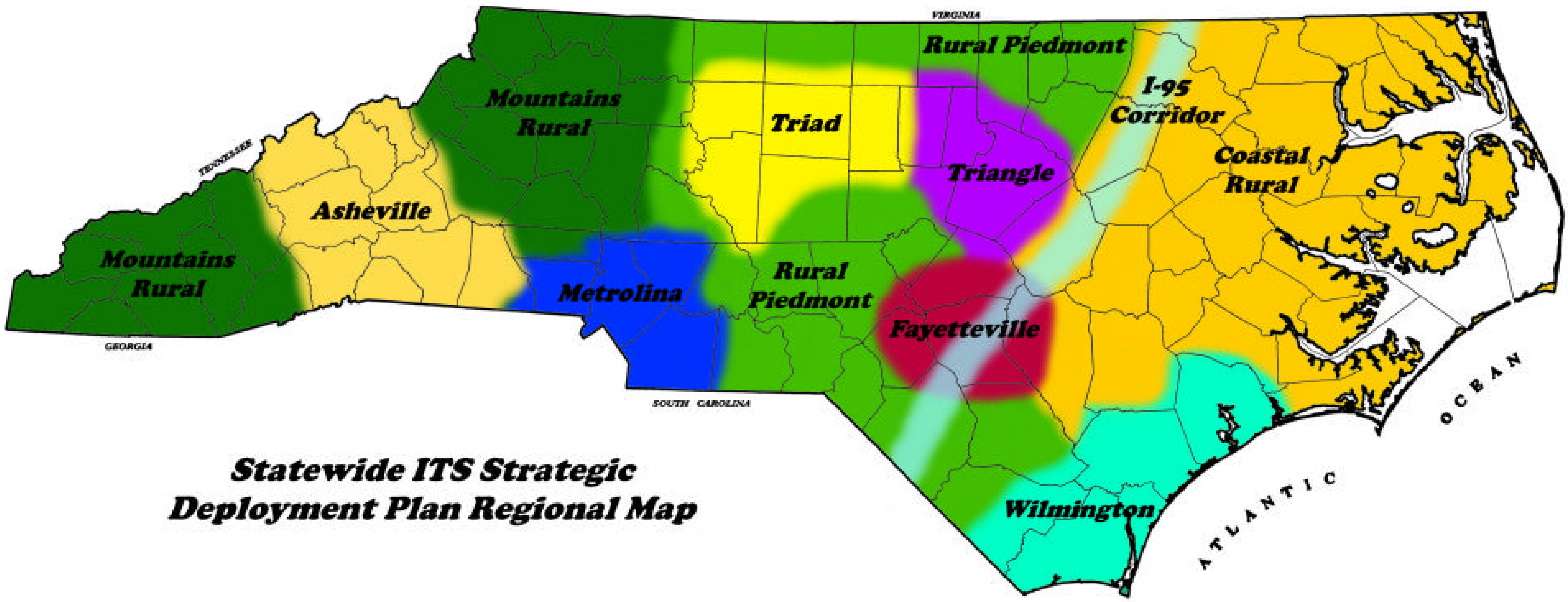


Figure 3. North Carolina ITS Strategic Deployment Plan Regions

- ITS Integration – acceleration of the integration and interoperability of ITS
- CVO Infrastructure Deployment – advancing technological capability and promoting ITS in the trucking industry
- ITS Research and Development – specifically includes funding for ITS services, among other program areas

TEA-21 lists several requirements for project funding, including:

- Contribute to national deployment goals and objectives
- Demonstrate strong commitment among stakeholders
- Maximize private sector involvement
- Demonstrate conformity to NIA and approved ITS standards and protocols [2]
- Be included in statewide or metro area transportation plans
- Ensure continued long-term operations and maintenance
- Demonstrate that personnel have necessary technical skills

Statewide ITS Goals

The overarching goal of NCDOT's ITS program is to support the Department's mission to "provide and support an integrated transportation system and related services that enhance the State's well-being."

Adding specific goals for the statewide ITS program to this mission statement, the following guiding principles that support this overall mission have been identified:

- Increase motorist safety and security
- Preserve infrastructure and services
- Ensure transportation system efficiency
- Increase economic development opportunities
- Incorporate the ideas and concerns of a broad cross-section of stakeholders in the State's transportation system
- Provide both static and dynamic transportation information, including road conditions, closures, and incident status updates
- Develop a mechanism to facilitate the sharing of information between NCDOT and other public and private agencies

[2] Note that at the time of passage of TEA-21, and at present in early 2001, the NTCIP Protocols and other ITS Standards are not all in place and established standards

In addition to these seven goals that have guided the preparation of each of the nine regional ITS Strategic Plans in the State, there is an element of incorporating ITS technologies into the overall toolbox of solutions to transportation problems. The eight goals of the Department, and the objectives that ITS helps to fulfill to meet those goals, are as follows:

- Goal 1: Provide a safe and well-maintained transportation system that offers modal choices for the movement of all people and goods.

  ITS Objective: Use ITS technologies to provide information among modes of routes, schedules, incidents, fares, real-time vehicle tracking, and other traveler and shipper information.

- Goal 2: Provide quality customer service.

  ITS Objective: Use advanced technologies available in ITS solutions to provide "user friendly" interface between users and transportation systems and services.

- Goal 3: Develop efficient processes to provide quality transportation services.

  ITS Objective: Investigate ITS technologies and applications in appropriate projects to provide innovative and flexible solutions and incorporate those technologies where cost-benefit ratios are greater than other solutions.

- Goal 4: Demonstrate responsible stewardship of fiscal resources.

  ITS Objective: Compare ITS solutions to new capacity solutions in order to obtain the most cost-effective use of available funding.

- Goal 5: Demonstrate responsible stewardship of other resources.

  ITS Objective: Assess the environmental, energy consumption, aesthetic, and other impacts of ITS technology deployment as compared to other transportation solutions.

- Goal 6: Support the development of sustainable, vibrant communities.

  ITS Objective: Incorporate the entire ITS stakeholder base into local community efforts to support sustainable community initiatives.

- Goal 7: Maintain a quality workforce.

  ITS Objective: Use the technological skills of communications and electronics engineers to upgrade the level of technical expertise in the Department and upgrade other disciplines with cross-training in ITS technology applications.

- Goal 8: Make decisions in a manner that builds trust and mutual respect.

  ITS Objective: Develop strong, effective partnerships within the various units of the Department.

Regional ITS Goals

Two types of regional ITS goals are identified in this document: short-term and long-term.

Short-term

Short-term goals focus on improving safety and security for the traveling public in all modes of surface transportation, and increasing the quantity and quality of relevant, timely travel and traffic information to the public. Short-term goals also concentrate on building up the “human capital” resources with improved training of personnel in technical disciplines and the development of better, cost-effective ways of establishing partnerships among public agencies and between the public and private sectors to deploy ITS projects in the State. Specific short-term principles to apply as goals include:

- Increasing motorist safety and security
- Preserving infrastructure and services
- Ensuring transportation system efficiency
- Incorporating all stakeholders’ input in the planning process

Long-term

Long-term goals involve many larger projects that actually start in the short-term. These larger scope projects require a significant investment in infrastructure, planning, and coordination. A new, regional TMC, a network of advanced weather information stations, or a statewide weigh-in-motion (WIM) and truck safety system will be considered projects that fit under long-term ITS goals.

Long-term goals include all the principles applied in the short-term, plus:

- Increase opportunities for economic development

National ITS Architecture

All projects that will use federal ITS funds require the development of a regional and/or statewide ITS architecture that meets the needs and criteria set forth by the NIA. As such, the regional and statewide deployment plans require that an ITS architecture be developed. The process of developing an architecture is briefly discussed earlier in this document, in the ITS Planning Process section. A detailed description of the NIA process, goals and objectives is included in the Appendix.

Stakeholder Input Process

Figure 1 shows the multiple steps that are involved in the stakeholder input process. The first step is to establish a stakeholder coalition to develop the vision and define the goals and objectives of the plan, as well as to identify any problems. The stakeholder input process involved multiple meetings and forums with key persons and agencies. Further information on the meetings and attendees is provided in the Appendix.

Despite differences among the regions with respect to how many meetings were held, in general, the meetings in each region occurred in the following order:

Regional Kick-Off/Consensus-Building Meeting. The first task in each region was to hold a regional kick-off/consensus-building meeting. These meetings typically included NCDOT representatives from the region, city and local transportation planners and engineers, and other interested key individuals. The intent of these meeting was to briefly introduce the project and overall statewide goals, customize the deployment planning process for each region, and identify the key public and private stakeholders within the region.

Planning Sessions. Multiple presentations occurred after the project kick-off meeting and prior to the summit meeting in each region. These presentations typically included briefings of the Technical Coordinating Committee (TCC) and Transportation Advisory Committee (TAC) in each region, and the presentation of ITS information to other key transportation groups and officials in the region. The purpose of these presentations and briefings was to promote ITS goals, provide a brief overview of the benefits of ITS, and inform people about the upcoming summit in the region.

Regional Summit. One to four regional summits were held in each of the nine regions. Stakeholders in the regions were invited to these half-day events that featured a presentation of the project background, information regarding the benefits of ITS, and an opportunity for the stakeholders to share and document their key issues.

Regional Team Meetings. Regional team meetings involved a group of key transportation stakeholders and decision-makers in the region. These meetings were used to establish the existing ITS deployments, prioritize regional needs identified in the summit meetings, and develop short- and long-term packages for deployment.

User Services and Market Packages

The goal of the stakeholder process was to develop a strategic plan of projects that can be implemented that also meet the transportation needs expressed by the stakeholders. Through the development of the NIA, the FHWA has identified 31 user services for urban areas, and 63 market packages that describe projects, and also identifies the information that must be shared between the various components. The process of identifying user services is shown in **Figure 4**.

The overall system architecture can be developed by selecting the appropriate user services and market packages. Grouping these packages together produces the overall system architecture and shows the data that must pass between elements and agencies. The user services generate categories of projects, such as traveler information. The packages are more specific types of projects.

There are seven critical program areas within ITS. Those seven programs are:

Traveler Safety and Security - Technologies use a in-vehicle sensors and information systems to alert drivers to hazardous conditions and dangers. This program features wide-area information dissemination of site-specific advisories and warnings.

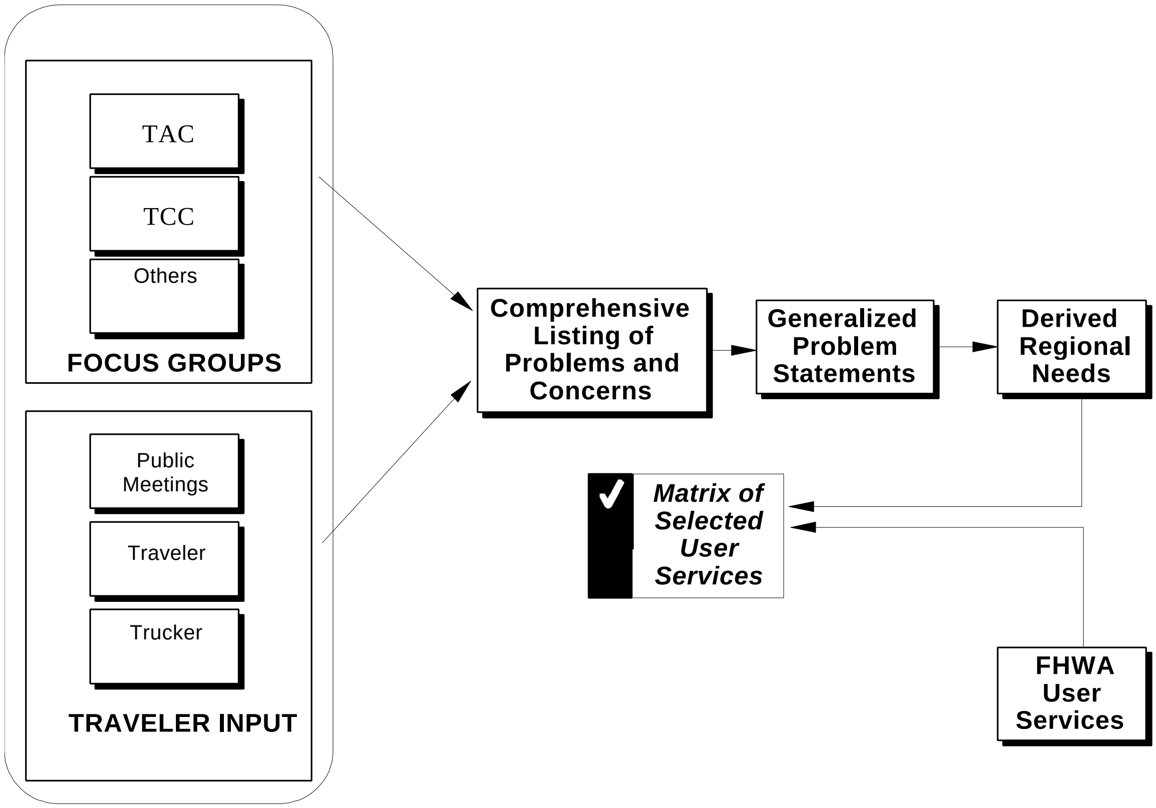


Figure 4. Identification of Needs and User Services

Tourism and Travel Information Services - Use in-vehicle navigation and roadside communication systems to provide information to travelers who are unfamiliar with the local areas. These services can be provided at specific locations, en-route, or prior to departure.

Public Traveler/Mobility Services - Improves the efficiency of transit services and their accessibility to residents. These services include better scheduling, improved dispatching, Smart Card readers and payment, and computerized ride-sharing systems.

Emergency Services - Use satellites and advanced communications systems to automatically notify the nearest police, fire, or rescue squad in case of collision or other emergency.

Fleet Operations and Management - Improves the efficiency of fleets of vehicles that operate in urban areas, such as utility readers, package delivery services, mail carriers, law enforcement, etc.

CVO - Satellites, computers, and communications systems manage the movement and logistics of commercial vehicles, and locate and track these vehicles during emergencies.

Infrastructure Operations and Maintenance - Improve the ability of highway workers to maintain and operate urban streets more efficiently. These services include severe weather information and immediate detection and alerting the public to dangers such as the presence of work zone crews.

The NIA lists potential ITS market packages to go with these critical program areas. There currently are 63 market packages in the NIA. **Table 1** lists specific market packages that are applicable to the Triangle Region based on the stakeholders meetings.

The following example illustrates the benefit of this categorization of market packages. The Regional ITS Summit in the Triangle Region identified the issue of providing traveler information by using kiosks. Various types of two-way communications devices were discussed. These transportation information needs were translated into consolidated information that can be provided to the traveling public with two-way capability. Affected ITS critical program areas would include Tourism and Traveler Information as the major component. Within the Tourism and Traveler Information program area, for example, the following market packages were determined to be applicable:

- Broadcast traveler information
- Interactive traveler information
- Yellow pages and reservations
- Autonomous route guidance
- In-vehicle signing

Traffic information dissemination is another market package that is listed in the NIA as belonging in the infrastructure operations and maintenance area, and this market package also is applicable.

By identifying these five as the primary market packages to meet the needs of metro area travelers, the specific data and communication issues can be identified at an early step. The way that subsystems, technology packages, and market packages fit together in a regional ATIS architecture is shown in **Figure 5**.

The interactive traveler information market package exemplifies the market packages that are applicable to urban regional ITS architectures. This market package provides tailored information in response to traveler requests. Users can request and obtain current information on traffic conditions, traveler services, and parking. A range of two-way, wide-area wireless, and wireline communications systems may be used to support the required digital communications between traveler and the information service provider. A variety of interactive devices may be used by the traveler to access information prior to a trip or en-route including plain old telephone (POT) service; traveler information kiosks in welcome centers, truck stops, etc.; Personal Digital Assistant (PDA); home computers; and a variety of in-vehicle devices.

The successful deployment of this market package relies on the availability of real-time transportation data from the Transportation Management System (TMS) or Transportation Regional Management System (TRMS). This market package also requires an entity (or entities) to process and disseminate the information - the information service provider (ISP). The ISP interfaces with the remote traveler support subsystem and personal information access subsystem to receive individual travelers' requests and respond with information. **Figure 6** shows the Interactive Traveler Information market package. Note that the information flows to the vehicle are displayed with dotted lines. This interface will probably not be available until the mid- or long-term timeframe (depending upon how quickly services become available nationally).

Table 1. ITS User Services Based on Typical Needs in Urban Areas

Critical Program Areas	**Specific ITS Market Packages** (Taken from the *ITS National Program Plan and National Architecture*, as amended)
Traveler Safety and Security	Traveler Security Intersection Safety Warning Intersection Collision Avoidance
Tourism and Travel Information	Broadcast Traveler Information Interactive Traveler Information Yellow Pages and Reservations Autonomous Route Guidance In-vehicle signing
Public Traveler/Mobility Services	Multimodal Traveler Information Demand Response Transit Operations Transit Passenger and Fare Management Transit Security Transit Maintenance
Commercial Vehicle Operations	CVO Fleet Administration /Coordination Freight Administration Fleet Administration Electronic Clearance HAZMAT Management
Emergency Services	Emergency Response Emergency Routing Mayday Support
Infrastructure Operations and Maintenance	Incident Management Traffic Information Dissemination Probe Surveillance Traffic Forecast and Demand Management Advanced Railroad Grade Crossing Road Weather Information System
Other	ITS Planning

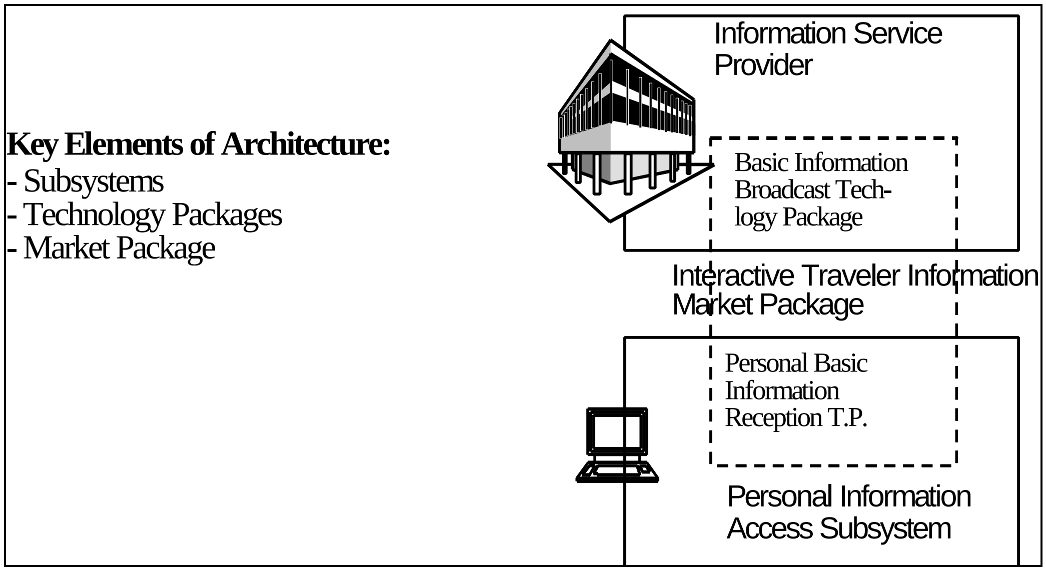


Figure 5. Relationship of Market Packages, Technology Packages, and Subsystems.

The user services and market packages are traceable directly to the architecture definition. Once a market package is selected for implementation, the required subsystems, equipment packages, and interface requirements may be identified. The benefit of this approach is that it allows the agency or organization deploying the technology to first consider deployment options and later concentrate on those pieces of the architecture necessary to support the selected deployment.

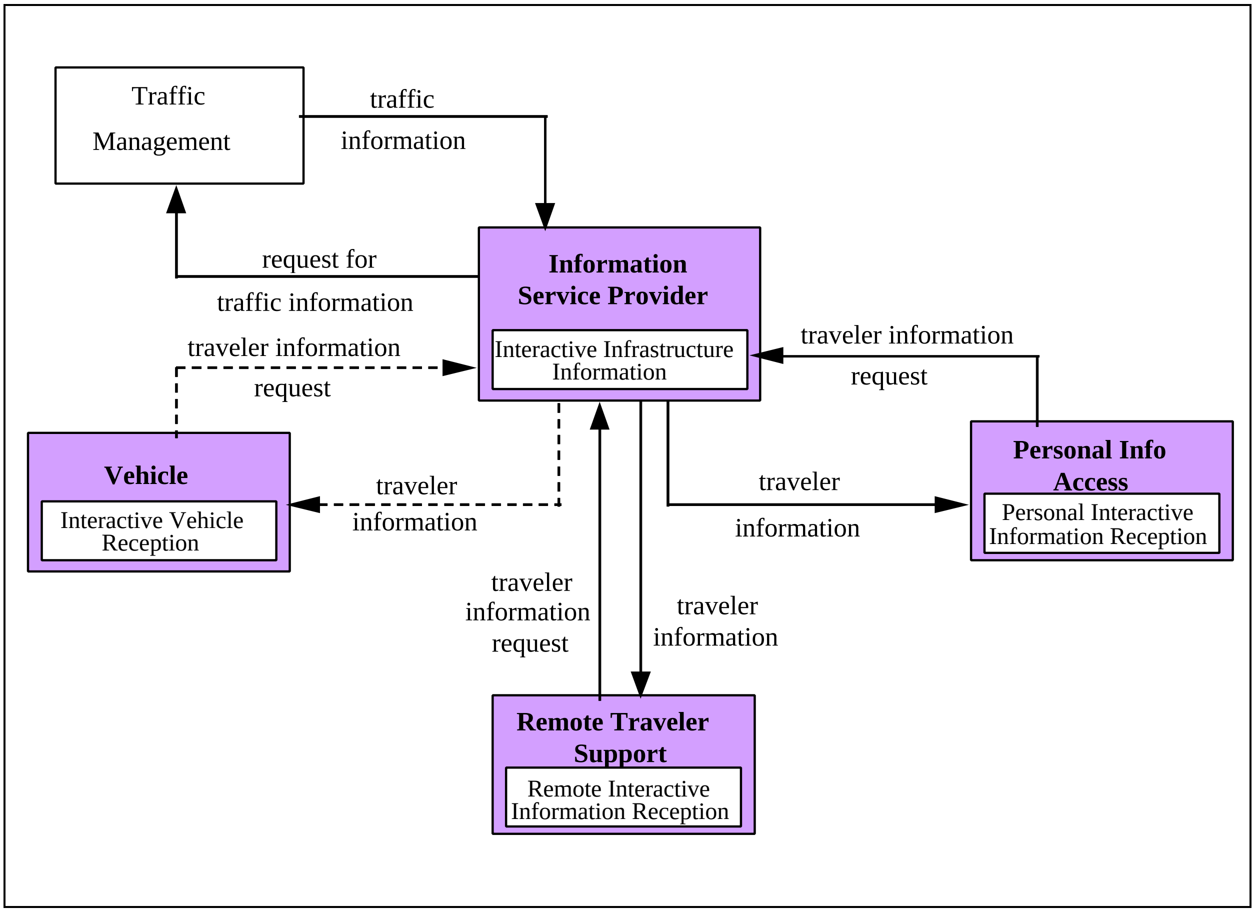


Figure 6. Interactive Traveler Information Market Package

Regional Overview

The Triangle Region encompasses Wake, Durham and Orange Counties, and a portion of Johnston County. It has a population of approximately 941,000 people, and includes the area surrounding the cities of Raleigh, Durham, and Chapel Hill. Other cities in the Triangle Region include: Cary, Garner, Apex, Wake Forest, Carrboro and Clayton. The major cities, roadways, and other key features of the Triangle Region are shown in **Table 2**.

Table 2. Triangle Region General Information.

County	NCDOT Division	Population	Major Cities	Major Roads	Military/Universities
Wake	5	591,000	Raleigh	I-40, I-440	NC State University
			Cary	US 1, US 64, US 70, US 264	Peace College
			Garner	US 401	Shaw University
			Apex	NC 42, NC 50, NC 54, NC 55	Wake Tech College
			Wake Forest	NC 96, NC 97, NC 98	Meredith College
					St. Augustine's College
Durham	5	205,000	Durham	I-40, I-85	Duke University
				US 15, US 70, US 501	NC Central University
				NC 54, NC 55, NC 751	
Orange	7	112,000	Chapel Hill	I-40, I-85	UNC-Chapel Hill
			Carrboro	US 15, US 70	
				NC 49, NC 54, NC 57, NC 86	
Johnston	4	33,000	Clayton	I-40	
(~30%)				US 70, US 301, US 701	
				NC 39, NC 42, NC 50, NC 210	
				NC 222	

Overview of ITS in the Region

Although relatively new, there are many ITS deployments that are either fully functional, in construction, or in the planning stages throughout the state. As part of the process, an inventory of all of these projects was performed. **Table 3** lists the deployed, planned, and programmed ITS projects in the Triangle Region. At the heart of the existing deployments in the Triangle Region is the Triangle Regional Transportation Management Center (TRTMC). This center currently manages the system of cameras and message boards on I-40 and in the future will be the central hub for the entire Triangle Region ITS Architecture.

The deployed, planned, and programmed elements are shown schematically in **Figure 7**. This figure shows the relationships between the elements and the various management centers, as well as the current connections between the centers.

TIP/STIP Project Listing

NCDOT Division 5 has an aggressive plan for ITS deployment over the next few years, including numerous projects that are on the Transportation Improvement Plan (TIP) as well as some that projects are planned but not funded. These projects are all listed and described in this section. Some of the projects included in **Table 4**, are included as recommended short- and long-term deployments listed later in this document.

Table 3. Triangle Region Existing ITS Deployments

LEGEND

Existing
Planned/Under Construction

Freeway Management

- Triangle Regional Transportation Management Center (TRTMC) in Raleigh monitors and operates 19 CCTV cameras along I-40, 8 CMS along I-40 and I-85, 3 HAR along I-40/I-85, I-40 and I-85

Incident and Event Management

- IMAP normal patrol routes include 29 miles on I-85 and I-40 and responds to and additional 47 miles on I-40, southern 440, I-85, I-540, US70, US15-501 and NC 147
- Edwards Mill Road reversible lanes for the Entertainment and Sports Arena

Traffic Signal Control

Closed Loop Signal Systems

- Knightdale – 19 signals on US64 in two closed loops – Peartree Lane to Rogers Lane, Old Milburnie Road to Square D (TIP # W-3601)
- Harrison Avenue in Cary from I-40 to Weston Parkway *(Extension to Maynard Road)*
- Town of Chapel Hill Signal System
- *Wake County – Falls of the Neuse Road/Durant Road at Outer Loop Interchange*
- *Wake County – Aviation Boulevard at I-40*
- *Apex/Holly Springs – NC 55, Hunter Street to Holly Springs Road*
- *Garner – US 401*, US 70

Citywide Signal Systems

- Raleigh – 458 signals in CBD, 441 on system, 3 CCTV in CBD, 12 signals programmed for transit preemption
- Orange County – 20 signals outside CBD
- *Durham Signal System Upgrade– 310 signals, 7 CCTV, 120 emergency preemption, traffic adaptive corridor (U-2927)*
- *Town of Cary Signal System*
- Town of Cary – preemption for police and fire vehicles through 11 signals – Kildaire Farm Road intersection

Transit Management

- Chapel Hill Transit – 56 buses, 7 demand-responsive
- Durham Area Transit – 40 buses, 29 demand-responsive
- Capital Area Transit
- Triangle Transit Authority and DATA telephones in vehicles can call Traffic Patrol Broadcasting to report congestion or incidents *(AVI/AVL to be funded – July 2000, 30 initial vehicles with expansion)*
- Raleigh-Durham International Airport shuttle
- Wolfline shuttle-*Main to Centennial Campus at NCSU*
- Wake County demand responsive
- Orange County demand responsive
- Wake County public schools – 35 service vehicles have AVL for incident response

Electronic Fare Payment

- Chapel Hill Transit – 56 buses with electronically registering fareboxes and magnetic stripe card readers
- Durham Area Transit – 32 buses with electronically registering fareboxes
- Triangle Transit Authority – 27 buses with electronically registering fareboxes (Smart Card study)
- Capital Area transit – all buses with electronically registering fareboxes and magnetic stripe card readers
- *Region-wide – Study to investigate use of SMART CARD on regional basis*

Emergency Management

Enforcement

- City of Raleigh PD – 194 vehicles, 130 under computer-aided dispatch
- City of Durham PD – 250 vehicles under computer-aided dispatch and mobile data terminals
- Wake County Sheriff – 200 vehicles
- Durham County Sheriff – 170 vehicles with mobile data terminals
- Orange County Sheriff – 86 vehicles
- Chatham County Sheriff – 53 vehicles
- Town of Cary PD – 52 vehicle with mobile data terminals
- NCSHP – 52 vehicles with mobile data terminals,rador and fast car detections, 6 vehicles with video cameras, 1 vehicle with accident reconstruction package
- NCDMV – 55 vehicles

Fire/Rescue

- City of Raleigh EMS – 27 vehicles under computer-aided dispatch
- City of Raleigh FD – 30 vehicles under computer-aided dispatch
- Wake County EMS – 40 vehicles
- Wake County Fire Marshall – 17 vehicles
- Wake County FD – 210 vehicles
- Town of Cary FD – 13 vehicles with mobile data terminals
- City of Durham FD – 32 vehicles under computer-aided dispatch and mobile data terminals
- City of Durham EMS – 19 vehicles under computer-aided dispatch
- Durham County EM and Fire Marshall – 7 vehicles under computer-aided dispatch
- Durham County FD – 33 vehicles under computer-aided dispatch
- 911 centers
- Statewide EM center

Table 3. (continued) EXSTING TRIANGLE ITS DEPLOYMENTS

LEGEND

Existing
Planned/Under Construction

Highway-Rail Intersections

- Raleigh/Durham – 27 signals with preemption capability

Regional Traveler Information

- Internet Web Sites – *www.ncsmartlink.org*, Traffic Patrol Broadcasting through WRAL-TV online
- Call-in Telephone – Traffic Patrol Broadcasting
- Cooperative Agreements for use of live video images– NCSHP, WRAL- TV, WTVD –TV, *NBC-17*, *Time-Warner*, and *Curtis Media Group*
- Carolina Trailways/Greyhound – 1-800 information number
- Triangle Transit Authority – Static fare, schedule, and route information on Internet *(Area Transit Information)*
- *Traveler information kiosks in state welcome centers (DOT/DOC partnership)*

Electronic Toll Collection

- None

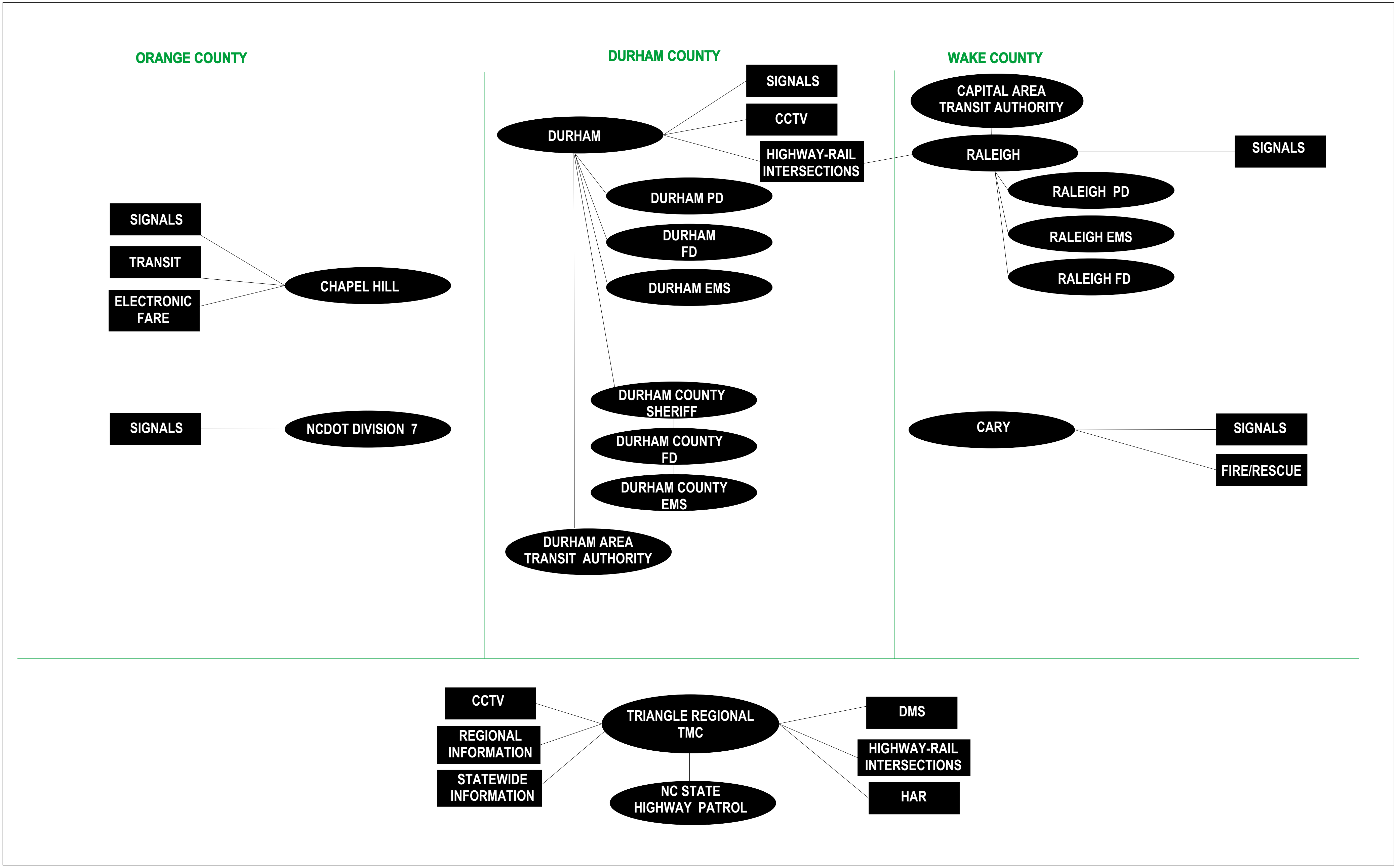


FIGURE 7 SCHEMATIC REPRESENTATION OF TRIANGLE REGION ITS ELEMENTS

Kimley-Horn and Associates, Inc.

Table 4. Funded Projects in Division 5 and 7.

Division 5			Division 7		
Funded			**Unfunded**		
Project Name	**Number**	**Cost**	**Project Name**	**Number**	**Cost**
I-85 CCTV1	I-0306DB	$2,036,253	Durham - US15-501	U-2807	$ 2,419,778
I-40 CCTV1	I-2204BA	$911,203	I-85 Communications2	I-0305A	$ 2,488,482
I-40 CCTV2	I-3306B	$5,556,484	I-85 Communications3	I-0305B	$ 2,511,758
SR 3009 Extension	U-2582B	$865,986			
DMS Funded Only					
Project Name	**Number**	**Cost**			
I-540 Communications1	R-2000AA	$1,769,770			
I-540 Communications2	R2000AB	$1,900,168			
I-540 Communications3	R-2000AC	$1,554,863			
I-540 Communications4	R-2000F	$2,758,735			
I-540 Communications5	R-2000G	$3,238,075			
S. Wake Expwy1	R-2721	$5,952,639			
S. Wake Expwy2	R-2828	$5,212,502			
E. Wake Expwy.Communications2	R-2829	$6,116,364			
W. Wake Expwy Communications	R-2635	$ 5,713,398			
Unfunded					
Project Name	**Number**	**Cost**			
I-85 Communications1	I-0306C	$2,375,673			
US 64 CCTV1	R-2547BA	$913,252			
US 64 (bypass) DMS	R-2547BB	$2,074,011			
US 64 DMS	R-2547C	$2,443,120			
US 64 CCTV2	R-2547CC	$1,287,388			
Durham N. Loop CCTV	R-2630A	$4,440,823			
Durham N. Loop DMS1	R-2630B	$4,314,789			
Durham N. Loop DMS2	R-2631B	$3,045,189			
E. Wake Expwy.Communications1	R-2641	$963,375			
New Route Communications	R-3330	$4,396,188			
I-40 Communications	T-002	$ 2,489,474			
I-440 Beltline Communications	T-003	$12,820,381			
NC 147 Communications	T-007	$ 3,690,700			
I-540 Communications6	R-2000S	$11,085,856			
Raleigh - I-440 Communications	U-2719	$ 2,442,525			

Division 5 Projects

The projects listed below are planned in Division 5. These projects - all of which are part of the recommended deployment in the Triangle Region over the next 10 years - have been broken down into funded and unfunded projects. Some of these projects have been included in the project list (**Table 4**). The costs have been provided by NCDOT as a preliminary estimate for construction.

Funded

I-85 CCTV1 (I-0306DB). Install one Closed Circuit Television (CCTV) camera and fiber optic cable and conduit along I-85 from west of Broad Street to west of Camden Avenue. This project is estimated to cost $2,036,253.

I-40 CCTV1 (I-2204BA). Install two CCTV cameras and fiber optic cable and conduit along I-40 from NC 147 in Research Triangle Park to I-540. This project is estimated to cost $911,203.

I-40 CCTV2 (I-3306B). Install four CCTV cameras, two dynamic message signs (DMS), and fiber optic cable and conduit along I-40 from Orange County Line to NC 147 (Durham Freeway). This project is estimated to cost $5,556,484.

SR 3009 Extension (U-2582B). Install two CCTV cameras, one DMS, and fiber optic cable and conduit between Raleigh – SR 3009 Extension Edwards Mill Road from south of SR 1728 Wade Avenue to SR 1664 Duraleigh. This project is estimated to cost $865,986.

DMS Funded Only

I-540 Communications1 (R-2000AA). Install one CCTV cameras, two DMS, and fiber optic cable and conduit along I-540 (Northern Wake Expressway) from NC 55 west of Morrisville to the east limits of the Research Triangle Park. This project is estimated to cost $1,769,770. **only the DMS are funded**

I-540 Communications2 (R2000AB). Install one CCTV camera, two DMS, and fiber optic cable and conduit between I-540 (Northern Wake Expressway) from the east limits of the Research Triangle Park to 0.6 miles southwest of I-40. This project is estimated to cost $1,900,168.

I-540 Communications3 (R-2000AC). Install one CCTV camera, four DMS, and fiber optic cable and conduit along I-540 (Northern Wake Expressway) from 0.6 miles southwest of I-40 to 0.1 miles southwest of I-40. This project is estimated to cost $1,554,863.

I-540 Communications4 (R-2000F). Install three CCTV cameras, two DMS, and fiber optic cable and conduit along I-540 (Northern Wake Expressway) from east of US 1 south of Perry Creek Road to south of Buffaloe Road. This project is estimated to cost $2,758,735.

I-540 Communications5 (R-2000G). Install three CCTV cameras, two DMS, and fiber optic cable and conduit between I-540 (Northern Wake Expressway) south of SR 2215 (Buffaloe Road) to US 64 East near Knightdale. This project is estimated to cost $3,238,075.

Southern Wake Expressway1 (R-2721). Install five CCTV cameras, four DMS, and fiber optic cable and conduit between Southern Wake Expressway from US 1 South to US 401 South. This project is estimated to cost $5,952,639.

Southern Wake Expressway2 (R-2828). Install four CCTV cameras, four DMS, and fiber optic cable and conduit between Southern Wake Expressway from US 401 to I-40. This project is estimated to cost $5,212,502.

Eastern Wake Expressway Communications2 (R-2829). Install five CCTV cameras, three DMS, and fiber optic cable and conduit along Eastern Wake Expressway from US I-40 to proposed US 64 bypass. This project is estimated to cost $6,116,364.

Western Wake Expressway Communications (R-2635). Install five CCTV cameras, three DMS, and fiber optic cable and conduit along Western Wake Expressway from US 1 South to NC 55. This project is estimated to cost $5,713,398.

Unfunded

I-85 Communications1 (I-0306C). Install two CCTV cameras, two DMS, and fiber optic cable and conduit along I-85 from east of SR 1401 Cole Mill Road to west of Broad Street. This project is estimated to cost $2,375,673.

US 64 CCTV1 (R-2547BA). Install one CCTV camera and fiber optic cable and conduit along US 64 from I-440 Raleigh Beltline to New Hope Road. This project is estimated to cost $913,252.

US 64 (Bypass) DMS (R-2547BB). Install two CCTV cameras, one DMS, and fiber optic cable and conduit between US 64 (Knightdale Bypass) from New Hope Road to east of SR 2601 (Clifton Road). This project is estimated to cost $2,074,011.

US 64 DMS (R-2547C). Install one CCTV camera, one DMS, and fiber optic cable and conduit along US 64 from East Wake Expressway to SR 2502. This project is estimated to cost $2,443,120.

US 64 CCTV2 (R-2547CC). Install one CCTV camera and fiber optic cable and conduit along US 64 from SR 2502 to existing US 64 east of SR 1003. This project is estimated to cost $1,287,388.

Durham N. Loop CCTV (R-2630A). Install five CCTV cameras, four DMS, and fiber optic cable and conduit between Durham Northern Loop/Eno Drive from I-85 west of Durham to US 501. This project is estimated to cost $4,440,823.

Durham N. Loop DMS1 (R-2630B). Install five CCTV cameras, four DMS, and fiber optic cable and conduit between Durham Northern Loop/Eno Drive from US 501 to I-85 northeast of Durham. This project is estimated to cost $4,314,789.

Durham N. Loop DMS2 (R-2631B). Install two CCTV cameras, one DMS, and fiber optic cable and conduit between Durham Northern Loop from I-85 northeast of Durham to NC 98 east of Durham. This project is estimated to cost $3,045,189.

East Wake Expressway Communications1 (R-2641). Install fiber optic cable and conduit along East Wake Expressway from the proposed US 64 bypass to US 64 East. This project is estimated to cost $963,375.

New Route Communications (R-3330). Install two CCTV cameras, two DMS, and fiber optic cable and conduit between the new route from Northern Wake Expressway to US 64 east of Knightdale. This project is estimated to cost $4,396,188.

I-40 Communications (T-002). The first phase of this project involves the installation of nine CCTV cameras and fiber optic cable and conduit between I-40 from Wade Avenue to I-440. This project is estimated to cost $2,489,474.

I-440 Beltline Communications (T-003). The first phase of this project involves the installation of 15 CCTV cameras, seven DMS, and fiber optic cable and conduit along I-440 Beltline. This project is estimated to cost $12,820,381.

NC 147 Communications (T-007). The first phase of this project involves the installation of seven CCTV cameras, two DMS, and fiber optic cable and conduit along NC 147 from I-40 to NC 55 and from US 15/501 to I-85. This project is estimated to cost $3,690,700.

I-540 Communications6 (R-2000S). Install five CCTV cameras, two DMS, and fiber optic cable and conduit between I-540 from 0.1 miles southwest of I-40 to east of US 1. This project is estimated to cost $11,085,856.

Raleigh - I-440 Communications (U-2719). Install two CCTV cameras and fiber optic cable and conduit along Raleigh – I-440 Cliff Benson Beltline from I-40 to north of SR 1728 Wade Avenue. This project is estimated to cost $2,442,525.

Division 7 Projects

The projects listed below are planned in Division 7. These projects - all of which are part of the recommended deployment in the Triangle Region over the next 10 years - have been broken down into funded and unfunded projects. Some of these projects have been included in the project list (**Table 4**). The costs have been provided by NCDOT as a preliminary estimate for construction.

Unfunded

Durham - US15-501 (U-2807). Install one CCTV camera and fiber optic cable and conduit along Durham – US 15-501 from SR 1010 Franklin Street in Chapel Hill to US 15-501 bypass in Durham. This project is estimated to cost $2,419,778.

I-85 Communications2 (I-0305A). Install two CCTV cameras and fiber optic cable and conduit along I-85 from SR 1006 near Hillsborough to the east of SR 1709. This project is estimated to cost $2,488,482.

I-85 Communications3 (I-0305B). Install two CCTV cameras and fiber optic cable and conduit along I-85 from east of SR 1709 to the Durham County Line. This project is estimated to cost $2,511,758.

Regional Strategic Deployment Plan Process

Meetings

To prepare and plan for the Triangle Regional summit, five consensus-building and planning meetings were held between August 17, 1999 and October 20, 1999. The minutes from these meetings are included in the Appendix.

The consensus-building meeting provided an overview of the entire project as well as the process for the regional and statewide plans. The meeting included a discussion of project specific issues, including:

- The perception of ITS in the Region
- Comments on the proposed process
- Identification of the stakeholders

The discussion helped to identify some of the key aspects of the project that needed to be carried forward throughout the process.

The planning meetings involved a more limited group of individuals than the consensus-building meeting. This group met to identify specific ITS projects in the region as well as numerous future needs that were carried over to the regional summit meetings, and provided the basis for the remainder of the strategic plan.

Summits

Following the initial planning and consensus-building meetings, a regional summit meeting was held on November 30, 1999.

The summit gave people from many backgrounds, along with transportation-related professionals, the opportunity both to learn more about ITS and to provide input on the specific needs that can be met using ITS products and technologies. Attendees included mayors, city and state traffic engineers, emergency services, schools, and major employers. Members of the news media also were invited. The minutes from this meeting are provided in the Appendix.

Regional Teams

The regional team meetings involved the same transportation professionals as the planning meeting. This team met twice during the course of the project. The first time (March 6, 2000) was to discuss the results of the summit and the architecture process. The second (April 11, 2000) was to review and comment on the regional deployment plan, and rank the potential projects.

Identification of Transportation Needs or Issues

As a result of the meetings, summits, and breakout groups, four key program areas for the Triangle Region were identified:

- Safety improvements
- Congestion/mobility/traffic management
- Advanced traveler information
- Interagency data exchange

The key transportation issues were identified based on the discussions of the various groups and the input from the regional teams. Sixty-five specific issues were identified in the transportation summits. Of the 65 needs, the following ten groupings or sub-categories were identified:

Traveler Information

- Too many single occupant vehicles
- Need access to traveler and transit information at work and public places
- Need web-based, real-time transit information
- Need more traffic conditions (including congestion status and incidents) radio broadcasts, including commercial radio and highway advisory radio (HAR), customized to the type of motorist
- Incident management should include all alternate routes
- Lack of 24-hour, real-time alternate route information
- Traveler information should include travel time estimates
- Need single access point to transit schedules by all transit providers
- Need complete, point-to-point, real-time transit route information
- Lack of 24-hour, accurate, location-specific pre-trip and en-route traveler information (route guidance)
- Need a centralized information clearinghouse with current traveler and road conditions information (weather, visibility-fog)
- Need web-based incident and closure information using Geographic Information System (GIS) based road maps
- Need more operational DMS with current traveler information
- Need advance warning of and better traffic control for work zones
- Keep motorists better informed of incident clearance measures
- Need traveler information customized to type of motorist
- Too many changes in travel mode
- Provide early warning of heavy truck traffic

CVO

- Need to reduce number of crashes involving commercial vehicles
- Need commercial vehicle and transit vehicle operating status/safety monitoring devices
- Need collision avoidance systems
- Need to equip commercial vehicles with more advanced in-vehicle ITS devices

- Need better commercial vehicle weight detection and enforcement
- Need web-based information for CVO, including easy access to truck restrictions information
- Need to improve personal safety of drivers
- Develop partnerships between CVO and law enforcement
- Need quicker commercial vehicle clearing at points of entry
- Need truck pre-clearance systems
- Need wireless communications capability for commercial vehicles
- Need in-vehicle driver monitoring systems
- Slow moving trucks
- Provide early warning of truck traffic
- Need real-time commercial vehicle status information
- Lack of clear policy on CVO data sharing
- Need real-time vehicle location information for trucks

Safety

- Need advance warning of and better traffic control for work zones
- Need to improve personal safety of transit users
- Need Mayday systems

Freeway Management

- Need to reduce freeway congestion
- Need improved traffic flow on freeways
- Need concentrated ITS deployments in corridors, including traffic surveillance
- Need ability to monitor system flow in real time
- Need improved queue clearing on freeway on-ramps
- Need to improve incident clearance measures and time
- Need to reduce number of crashes involving commercial vehicles
- Need to coordinate freeway incident management with surface street traffic control
- Need increased incident management patrols to complement automatic incident detection
- Need freeway lane control capability for better incident management
- Need to alleviate freeway traffic breakdown caused by merging drivers through ramp metering integrated with surface street control

Traffic Signal Control

- Improve signal progression to reduce travel time for commuters, including adding new signal coordination
- Need concentrated ITS deployments in corridors, including traffic surveillance
- Need ability to monitor system flow in real time
- Multi-jurisdictional signal coordination
- Need to coordinate freeway incident management with surface street traffic control
- Need signal preemption for emergency vehicles
- Need signal priority for transit vehicles
- Need to alleviate freeway traffic breakdown caused by merging drivers through ramp metering integrated with surface street control
- Improve automated rail crossing control systems

Transit

- Need to allow transit vehicles on high occupancy vehicle (HOV) lanes
- Need better integration of transit with other modes (school, commuter, park and ride)
- Increase incentives to use public transit
- Need web-based, real-time transit information
- Need to include ridesharing in transit management
- Can't get from city to city on transit

- Improve route choices for public transit
- Need signal priority for transit vehicles
- Need single access point to transit schedules by all transit providers
- Need complete, point-to-point, real-time transit route information
- Inadequate frequency of bus pickups
- Limited personalized, user-friendly options for transit users
- Need to improve personal safety of transit users
- Need better management of transit vehicles
- Improve automated rail crossing control systems

Operations and Maintenance

- Need ability to monitor system flow in real time
- Need to coordinate freeway incident management with surface street traffic control

Inter-Jurisdictional Coordination

- Multi-jurisdictional signal coordination
- Need to coordinate freeway incident management with surface street traffic control
- Can't get from city to city on transit
- Eliminate traffic delays at cross-jurisdictional lines

Emergency Management

- Need signal preemption for emergency vehicles
- Need up-to date Hazardous Material (HAZMAT) information
- Need real-time video feed from police and other emergency vehicles
- Need real-time, two-way data feeds for enforcement vehicles (mobile data terminals)
- Need Mayday systems

Parking Management

- Need advance parking availability information and advanced warning of reduced roadway cross-sections

Some of these needs fit in multiple categories and are shown as such.

Several needs that were not identified in the Triangle Regional summit were identified in one or more of the previous urban regional meetings. Some of these needs, and some identified in the urban summits, have been identified as linkages to statewide or "extra-regional" needs.

This information was grouped into market packages to develop a regional ITS architecture. This process is described in detail later in this report.

Regional Strategic Plan

The basic premise for this ITS Strategic Deployment Plan is to identify the transportation problems and needs in North Carolina and to select ITS technologies that can be used to address these needs. The ITS technology selection process begins with identifying appropriate ITS user services. User services represent functions performed by ITS technologies and organizations for the direct benefit of the traveling public.

The national ITS program plan defines the term *users* as: "a wide range of individuals and organizations including drivers, travelers, service providers, and transportation policy makers." The NIA currently defines 31 user services for urban areas. **Table 5** lists all 31 user services listed in the NIA and provides a brief definition.

Table 5. ITS User Services.

1	Pre-Trip Travel Information	*Provides information for selecting the best transportation mode, departure time, and route.*
2	En-Route Driver Information	*Provides advisories and in-vehicle signing for convenience and safety.*
3	Route Guidance	*Provides travelers with instructions on how to reach their destinations.*
4	Ride Matching and Reservation	*Makes ride sharing easier and more convenient.*
5	Traveler Services Information	*Provides a business directory, or "yellow pages," of service information.*
6	Traffic Control	*Manages the movement of traffic on streets and highways.*
7	Incident Management	*Helps quickly identify incidents and implement a response.*
8	Demand Management and Operations	*Supports policies to mitigate the environmental/social impacts of traffic.*
9	Emissions Testing and Mitigation	*Provides information for monitoring air quality.*
10	Highway Rail Intersection	*Provides improvements to automated crossing control systems.*
11	Public Transportation Management	*Automates operations, planning, and management of public transit.*
12	En-Route Transit Information	*Provides information on public transportation after the trips begins.*
13	Personalized Public Transit	*Provides flexibly routed transit to offer more convenient service.*
14	Public Travel Security	*Creates a secure environment for transportation patrons and operators.*
15	Electronic Payment Services	*Allows travelers to pay for transportation services electronically.*
16	CVO Electronic Clearance	*Facilitates domestic and international border clearance.*
17	Automated Roadside Safety Inspection	*Facilitates roadside inspections.*
18	On-Board Safety Monitoring	*Senses the safety status of a commercial vehicle, cargo, and driver.*
19	CVO Administrative Processes	*Provides electronic purchasing of credentials, etc.*
20	Hazardous Material Incident Response	*Provides immediate description of hazardous materials.*
21	Commercial Fleet Management	*Provides communication between drivers, dispatchers, and providers.*
22	Emergency Notification and Personal Security	*Provides immediate notification of an incident and immediate request for assistance.*
23	Emergency Vehicle Management	*Reduces incident response time for emergency vehicles.*
24	Longitudinal Collision Avoidance	*Helps prevent head-on, rear-end or backing collisions between vehicles, or between vehicles and other objects or pedestrians.*
25	Lateral Collision Avoidance	*Helps prevent collisions when vehicles leave their lane of travel.*
26	Intersection Collision Avoidance	*Helps prevent collisions at intersections.*
27	Vision Enhancement for Crash Avoidance	*Improves the driver's ability to see the roadway and objects that are on or along the roadway.*
28	Safety Readiness	*Provides warnings about the condition of the driver, vehicle, and roadway.*
29	Pre-Crash Restraint Deployment	*Anticipates an imminent collision and activates passenger safety systems before the collision occurs, or much earlier in the crash event than is currently feasible.*
30	Automated Vehicle Operation	*Provides a fully automated hands-off operating environment.*
31	Archived Data User Service	*Provides for automated historic data archiving and sharing.*

Regional Plan Development Methodology

The objective of this task was to determine, based on stakeholder input, which of the 31 ITS user services need to be implemented in the Triangle Region and how to phase their implementation (i.e., in the short- or long-term timeframes). Since delivering a user service takes more than just one piece of equipment, the ITS architecture groups equipment into market packages.

While user services help us define what is needed, their corresponding market packages describe how to provide those services. Each market package consists of a group of elements (equipment packages) that work together to deliver a particular user service. To identify the specific technology groups that will be needed to provide the selected user services, market packages corresponding to each selected user service were identified in this task.

The activities of this task were divided into three steps aimed at producing a well-defined, integrated user service plan, as follows:

- Identification and prioritization of applicable user services based on previously identified transportation needs of the region and development of user services deployment timeframes
- Development of specific user objectives and performance criteria
- Selection of market packages

The following section describes the above steps in more detail. The remainder of this section of the report provides a complete description of each activity associated with these steps.

The first step in this task focused on identifying the user services appropriate for North Carolina based on previously identified regional needs. First, the original statements of problems and concerns gathered through stakeholder meetings in each of the summits were assembled into a comprehensive list. Next, this list of original, raw statements was reduced and refined through grouping of similar statements into concise need statements. This step also eliminated those problem statements not directly related to transportation issues that could be related to ITS. Lastly, these needs were placed in a separate category of non-ITS related needs. Lastly these concise need statements were matched with appropriate ITS user services.

The Triangle Region's transportation-related needs, identified in the previous section, were matched, or mapped, with the 31 applicable ITS user services, resulting in a preliminary set of user services to be deployed specifically in the Triangle Region. Several overlapping needs that were identified in the other urban regions (Piedmont Triad and Metrolina) were carried over to the Triangle Region.

These user services were prioritized based on the relative ranking of each related need. The regional team provided the needs ranking, in terms of importance, during regional team meetings. Based on the priority ranking of each user service and using the common objectives and overlapping functionality of the user services, preliminary short- and long-term deployment timeframes for groups of user services were identified.

In the next step, system objectives were defined for each identified user service. A system objective identifies the improvements in the system that can be expected to occur as a result of the successful implementation of a user service. To judge the degree of success of the implementation of the user services, including the effectiveness of the deployed service or technology in solving the original problem, a set of performance criteria was developed.

Finally, to begin defining the physical ITS architecture for each region and for the state, market packages corresponding to the selected user services were identified. The 63 currently defined ITS market packages are an important building block of the statewide ITS architecture definition process and represent specific portions of the architecture that may be required to satisfy the needs identified by North Carolina stakeholders. Market packages and their definitions from the NIA are identified in Table A-2 in the Appendix.

Input Mapping to User Services

The transportation needs for the Triangle Region, as discussed in the previous section, were mapped to the user services categories in the NIA. The user services mapping is shown in **Table 6**.

Ranking of Identified Needs

The prioritization of user services was based on the relative ranking of each of the 65 needs identified by the stakeholders. The Triangle Region's transportation stakeholders, ranked the needs during the first regional team meeting.

The assignment of the need rankings (shown in **Table 7**) to the matched user services was accomplished by summing the point scores of all the needs corresponding to each matched user service as shown in **Table 6**. **Table 7** shows the ranking of these needs by stakeholders involved in the ITS project from the Triangle Region.

The score for each user service was expressed as a percentage of the total score (equal to the sum of scores for all user services), and plotted on a bar chart. **Figure 8** shows the resulting ranking of the user services receiving points. (The details of this methodology are provided in the Appendix).

The user services shown in **Figure 8** were identified as the most likely to achieve strategic planning success in the Triangle Region. This selection was not intended to exclude other user services as needed in specific areas. The list of user services does, however, represent recommendations of regional services on which the remainder of this strategic plan was based.

Table 6. MATCHING USER NEEDS TO ITS USER SERVICES

User Services

		Travel And Traffic Management										Public Transportation Management				Electronic Payment	Commercial Vehicle Operations						Emergency Management		Advanced Vehicle Safety Systems							Information Management	Other	
ID#	TRIANGLE AREA NEEDS	1.1 Pre-trip Travel Information	1.2 En-route Driver Information	1.3 Route Guidance	1.4 Ride Matching and Reservation	1.5 Traveler Services Information	1.6 Traffic Control	1.7 Incident Management	1.8 Travel Demand Management	1.9 Emissions Testing and Mitigation	1.10 Highway-Rail Intersection	2.1 Public Transportation Management	2.2 En-route Transit Information	2.3 Personalized Public Transit	2.4 Public Travel Security	3.1 Electronic Payment Services	4.1 Commercial Vehicle Electronic Clearance	4.2 Automated Roadside Safety Inspection	4.3 On-board Safety Monitoring	4.4 Commercial Vehicle Administrative Processes	4.5 Hazardous Material Incident Response	4.6 Commercial Fleet Management	5.1 Emergency Notification and Personal Security	5.2 Emergency Vehicle Management	6.1 Longitudinal Collision Avoidance	6.2 Lateral Collision Avoidance	6.3 Intersection Collision Avoidance	6.4 Vision Enhancement For Crash Avoidance	6.5 Safety Readiness	6.6 Pre-crash Restraint Deployment	6.7 Automated Vehicle Operation	7.1 Archived Data Function	8.1 Other	POTENTIAL PROJECTS
1	Lack of 24-hr, accurate, location-specific pre-trip and en-route traveler information (route guidance)		X			X																												Free traffic conditions data access for value-added private partners for digital broadcasts (SmartRoutes, TEAK, etc.)
2	Lack of 24-hr, real-time alternate route information		X	X																														VRAS - Voice Remote Access System to traveler information with touch button route and milepost selection. FM subcarrier incident location feeds to in-vehicle devices with map and alternate route databases. Centrally located alternate route database system. Commercial radio and HAR broadcasts with alt. route information. Internet based incident/closure location data with date, time, and alt. route suggestions.
3	Need more operational DMS with current traveler information		X				X																											Dynamic Message Signs(DMS) on freeways and arterials with frequent and accurate message updates.
4	Need more traffic conditions (including congestion status and incidents) radio broadcasts, including commercial radio, HAR, customized to type of motorist.		X			X	X																											AM and FM - based Highway Advisory Radio (HAR) (freeways and arterials), Kiosks in public places, FM radio station for traffic information
5	Need advance warning of and better traffic control for work zones	X	X	X			X															X												Portable DMS ahead of freeway construction sites. Inclusion of construction-zone/lane closure information in all modes of traveler information access, with frequent updates, through central information repository and dissemination system.
6	Need a centralized information clearinghouse with current traveler and road conditions information (weather, visibility-fog)	X	X	X			X					X																						Traveler information clearinghouse(s)
7	Need to provide real-time or near-real-time video of traffic conditions	X					X																											Closed circuit television cameras (CCTV) or still-frame cameras on freeways and along arterial corridors with feed to the Traffic Management Center(s)
8	Provide early warning of heavy truck traffic	X	X	X			X																											Strategically deployed system detectors working together with a TMC processing center to develop and post existing and predicted congestion locations to DMS and other traveler and traffic information dissemination media.
9	Need single access point to transit schedules by all transit providers											X	X																					Transit kiosks with transit schedule feeds from all transit providers.
10	Need web-based incident and closure information using GIS road maps	X																																Centralized closure and hwy restrictions database with real-time updates and GIS based internet user interface.
11	Need to alleviate freeway traffic breakdown caused by merging drivers through ramp metering integrated with surface street control.						X																											Ramp metering. Signal timing synchronization between ramp meters and adjacent traffic signals.
12	Need to reduce freeway congestion						X																									X		Ramp metering. DMS with advance warning of incidents ahead. Automated incident detection systems. Travel demand policies.
13	Eliminate traffic delays at cross-jurisdictional lines						X																									X		Delays due to lack of coordination of adjacent signals on each side of the jurisdictional border.
14	Multi-jurisdictional signal coordination						X																									X		Signal coordination along corridors spanning multiple jurisdictions.
15	Improve signal progression (including adding new signal coordination) to reduce travel time for commuters						X																									X		Signal timing optimization along corridors. New signal systems or TBC where non exist.
16	Need concentrated ITS deployments in corridors, including traffic surveillance						X																									X		System detectors, CCTV surveillance, and DMS along primary urban corridors. Signal coordination along primary corridors.
17	Need freeway lane control capability for better incident management						X	X																										Freeway lane control changeable signs.
18	Need improved traffic flow on freeways						X	X																								X		Ramp metering.
19	Need improved queue clearing on freeway on-ramps						X	X																								X		Ramp metering. Signal timing synchronization between ramp meters and adjacent traffic signals.
20	Need ability to monitor system flow in real time						X																									X		Loop, acoustic, radar system detectors on freeways.
21	Need signal preemption for emergency vehicles						X																	X										Signal preemption for emergency vehicles.
22	Need signal priority for transit vehicles						X					X																						Signal system software and hardware upgrades to accommodate bus priority processing.
23	Need to allow transit vehicles on HOV lanes.						X																											Signing issue.
24	Need to coordinate freeway incident management with surface street traffic control						X	X																										Real-time incident status notification and update to TMC signal operators. Automated signal priority system for emergency vehicles.
25	Too many single occupancy vehicles								X																							X		Congestion pricing strategies (HOV lane use toll, toll lanes, parking fees). Upgrades to transit system operations - more efficient transit systems using modern dispatching methods and AVL for buses.
26	Too many changes in travel mode											X																						Improvements to transit route planning through state of the art demand forecasting models. Efficient multi-modal (car/bus/train/subway/tram) centers.
27	Need advance parking availability information and advanced warning of reduced roadway cross-section	X	X			X			X							X																		Parking management systems. Electronic data sharing between parking mgt systems and traveler information clearinghouse.
28	Need access to traveler and transit information at work and public places.	X										X																						Traveler information kiosks located at high-pedestrian traffic areas (office buildings, banks, stores, hotels, restaurants, visitor centers, chambers of commerce, etc.)
29	Need traveler information customized to type of motorist	X	X	X																		X												Centralized traveler information clearinghouse with interactive, custom information filters.
30	Need web-based real-time transit information	X										X																						Internet interface to the central traveler information clearinghouse.
31	Traveler information should include travel time estimates	X	X	X								X																						Travel time estimation element of the centralized traveler information clearinghouse. Require private, value added information distributors to provide travel time estimations based on traveler queries.
32	Need better integration of transit with other modes (school, commuter, park & ride)				X							X																						Improvements to transit route planning through state of the art demand forecasting models. Efficient multi-modal (car/bus/train/subway/tram) centers. Shared, real-time demand tracking databases. Modern transit dispatching centers. Advanced demand estimation modeling based on archived data.
33	Need complete, point-to-point, real-time transit route information	X										X	X	X																				Transit kiosks. Internet transit schedule/route dissemination with maps and origin-destination route inquiries.
34	Need web-based information for CVO including easy access to truck restrictions information																																	Information kiosks at truck stops. Web based truck restrictions map / listing displays with querying capabilities. Current fwy/lane closure information exchange between FMS and CVO dispatching centers. Remote voice access to current truck restrictions information.
35	Need to include ridesharing in transit management				X							X																						Upgrades to transit public information system. Web and voice based rideshare systems tied to transit schedules.
36	Limited personalized, user-friendly options for transit users													X																				In-bus real-time schedule and route displays. Customizable web-based transit information. Transit kiosks with custom query capability.
37	Better maintenance of transit vehicles											X																						Vehicle status monitoring devices.
38	Can't get from City to City on Transit											X				X																		Regional Smart Card system to share and automatically collect transit fares.
39	Improve route choices for public transit	X										X	X	X																				Improvements to transit route planning through state of the art demand forecasting models. Efficient multi-modal (car/bus/train/subway/tram) centers. Shared, real-time demand tracking databases. Modern transit dispatching centers. Advanced demand estimation modeling based on archived data.

Table 6. MATCHING USER NEEDS TO ITS USER SERVICES

ID#	TRIANGLE AREA NEEDS	1.1 Pre-trip Travel Information	1.2 En-route Driver Information	1.3 Route Guidance	1.4 Ride Matching and Reservation	1.5 Traveler Services Information	1.6 Traffic Control	1.7 Incident Management	1.8 Travel Demand Management	1.9 Emissions Testing and Mitigation	1.10 Highway-Rail Intersection	2.1 Public Transportation Management	2.2 En-route Transit Information	2.3 Personalized Public Transit	2.4 Public Travel Security	3.1 Electronic Payment Services	4.1 Commercial Vehicle Electronic Clearance	4.2 Automated Roadside Safety Inspection	4.3 On-board Safety Monitoring	4.4 Commercial Vehicle Administrative Processes	4.5 Hazardous Material Incident Response	4.6 Commercial Fleet Management	5.1 Emergency Notification and Personal Security	5.2 Emergency Vehicle Management	6.1 Longitudinal Collision Avoidance	6.2 Lateral Collision Avoidance	6.3 Intersection Collision Avoidance	6.4 Vision Enhancement For Crash Avoidance	6.5 Safety Readiness	6.6 Pre-crash Restraint Deployment	6.7 Automated Vehicle Operation	7.1 Archived Data Function	8.1 Other	POTENTIAL PROJECTS
		User Services: Travel And Traffic Management										Public Transportation Management				Electronic Payment	Commercial Vehicle Operations						Emergency Management		Advanced Vehicle Safety Systems							Information Management	Other	
40	Inadequate frequency of bus pickups											X																						Advanced demand estimation modeling based on archived data. Dynamic bus scheduling and route adjustment.
41	Increase incentives to use public transit											X				X																		Improvements to the efficiency of the existing transit system.
42	Need to improve personal safety of transit users														X																			Audio and video monitoring at bus stops. Emergency phones at bus stops.
43	Keep motorists better informed of incident clearance measures	X	X	X				X														X		X										Incident removal status in the traveler information stream.
44	Incident management should include all alternate routes							X																										State of the incident management system with dynamic alternate route selection.
45	Need increased IMAP to compliment automatic incident detection							X															X											Fund additional IMAP units.
46	Need to improve incident clearance measures and time							X															X	X										Automatic incident detection and notification systems. CCTV-based incident verification. AVL and MDT for emergency vehicles.
47	Need mayday systems!							X															X	X										MAYDAY systems for rural corridors: region/statewide partnerships with CVO for location-accurate incident reporting; freeway call boxes; call boxes off the hwy system; in-vehicle crash detection and notification; modernized PSAP call location verification.
48	Need real-time two-way data feeds for enforcement vehicles																							X										State of the art MDTs and broadband wireless communications for emergency vehicles.
49	Need real-time video feed from police and other emergency vehicles																							X										In-vehicle CCTV and broadband synchronous wireless communications.
50	Need to improve personal safety of drivers		X	X		X																	X											Rest area security. In-vehicle driver monitoring devices.
51	Lack of clear policy on CVO data sharing																X			X														Implement CVISN
52	Develop partnerships between CVO and law enforcement																X	X			X	X												Implement CVISN
53	Need better CV weight detection and enforcement																X	X																Non-POE WIM with automatic law enforcement notification.
54	Need quicker CV clearing at POEs																X																	State of the art CVO electronic clearance systems (like PrePass).
55	Need real-time CV vehicle status information																X	X	X										X					In-vehicle monitoring devices for CVO. AVL for CVs. Wireless commas for CVs.
56	Need truck pre-clearance systems																X																	Pre-clearance systems.
57	Need real-time vehicle location information for trucks																					X												AVL for CVs.
58	Need wireless communications capability for CVs																X					X												Wireless communications for CVO. Additional cellular towers.
59	Need up-to date HAZMAT information							X													X													HAZMAT information clearinghouse.
60	Need collision avoidance systems																								X	X	X							Install in-vehicle collision avoidance devices in public agency fleets
61	Slow moving trucks						X										X																	CVISN to permit trucks to bypass weigh stations. Clearer definition of truck routes to guide trucks to their proper destination.
62	Need in-vehicle driver monitoring systems																												X					Install in-vehicle driver condition monitoring systems for public agency maintenance trucks. Promote use.
63	Need to equip CV with more advanced in-vehicle ITS devices																		X						X	X	X	X	X					Collision avoidance, driver condition monitoring, automated maintenance reporting systems, enhanced vision systems, etc. in CVs.
64	Need to reduce number of crashes involving CVs						X												X						X	X	X	X	X					Collision avoidance systems in CVs and in passenger vehicles. Roadside speed displays. Speed enforcement.
65	Need CVO and transit vehicle operating status/safety monitoring devices.																		X										X					In-vehicle system monitoring devices.

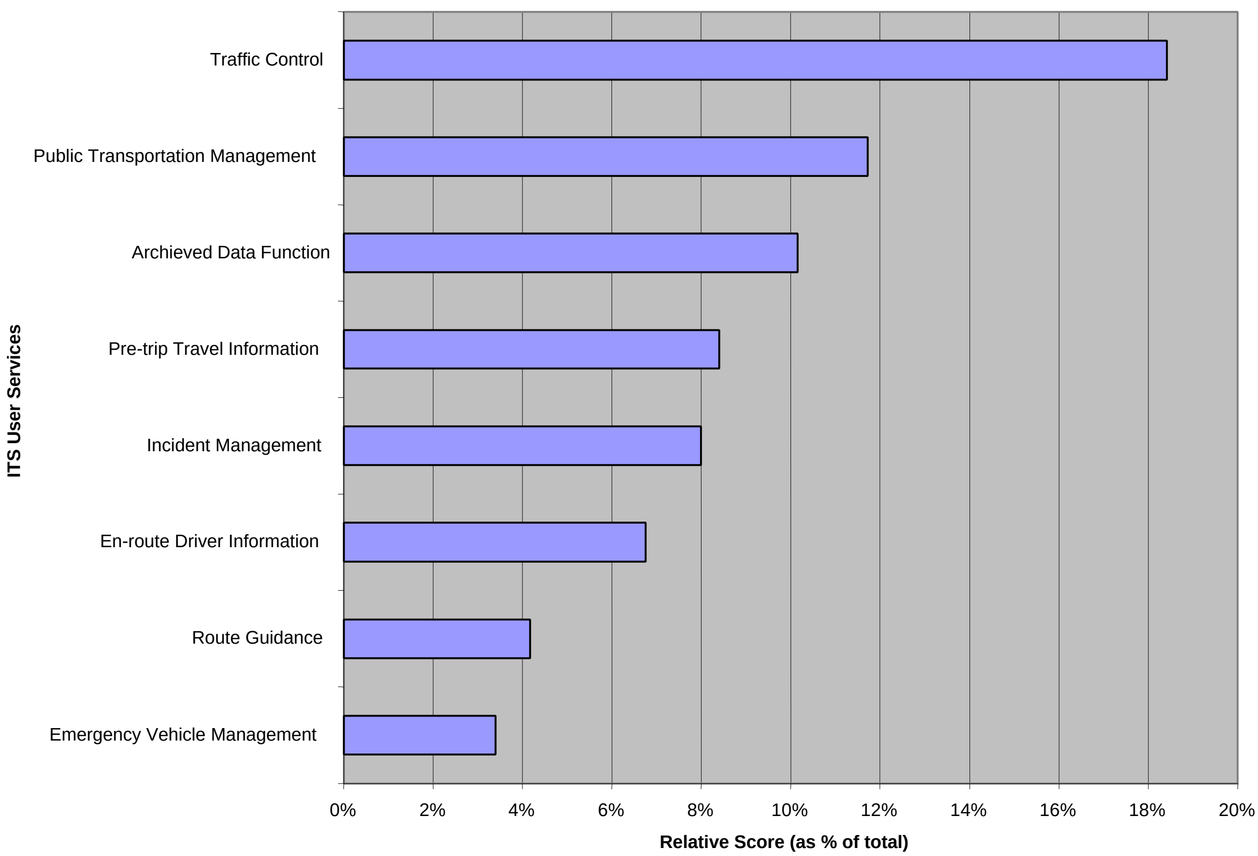
Table 7. Coalition Ranking of Identified Needs (by Score).

ID #	IDENTIFIED ISSUE	PRIORITY
12	Need to reduce freeway congestion	1
15	Improve signal progression (including adding new signal coordination) to reduce travel time for commuters	2
18	Need improved traffic flow on freeways	3
25	Too many single occupancy vehicles	4
23	Need to allow transit vehicles on HOV lanes	5
16	Need concentrated ITS deployments in corridors, including traffic surveillance	6
20	Need ability to monitor system flow in real time	7
28	Need access to traveler and transit information at work and public places.	8
32	Need better integration of transit with other modes (school, commuter, park & ride)	9
41	Increase incentives to use public transit	10
14	Multi-jurisdictional signal coordination	11
19	Need improved queue clearing on freeway on-ramps	12
30	Need web-based real-time transit information	13
35	Need to include ridesharing in transit management	14
46	Need to improve incident clearance measures and time	15
64	Need to reduce number of crashes involving commercial vehicles	16
4	Need more traffic conditions (including congestion status and incidents) radio broadcasts, including commercial radio, HAR, customized to type of motorist.	17
24	Need to coordinate freeway incident management with surface street traffic control	18
44	Incident management should include all alternate routes	19
2	Lack of 24-hr, real-time alternate route information	20
31	Traveler information should include travel time estimates	21
38	Can't get from City to City on Transit	22
39	Improve route choices for public transit	23
45	Need increased incident management patrols to complement automatic incident detection	24
13	Eliminate traffic delays at cross-jurisdictional lines	25
17	Need freeway lane control capability for better incident management	26
21	Need signal preemption for emergency vehicles	27
22	Need signal priority for transit vehicles	28
66	Improve automated rail crossing systems	29
9	Need single access point to transit schedules by all transit providers	30
33	Need complete, point-to-point, real-time transit route information	31
7	Need to provide real-time or near-real-time video of traffic conditions	32
1	Lack of 24-hr, accurate, location-specific pre-trip and en-route traveler information (route guidance)	33
6	Need a centralized information clearinghouse with current traveler and road conditions information (weather, visibility-fog)	34
10	Need web-based incident and closure information using GIS road maps	35

Table 7. Coalition Ranking of Identified Needs (by Score). ***(continued)***

ID #	IDENTIFIED ISSUE	PRIORITY
3	Need more operational variable message sign with current traveler information	36
40	Inadequate frequency of bus pickups	37
5	Need advance warning of and better traffic control for work zones	38
43	Keep motorists better informed of incident clearance measures	39
65	Need commercial vehicle and transit vehicle operating status/safety monitoring devices.	40
11	Need to alleviate freeway traffic breakdown caused by merging drivers through ramp metering integrated with surface street control.	41
59	Need up-to date HAZMAT information	42
36	Limited personalized, user-friendly options for transit users	43
42	Need to improve personal safety of transit users	44
49	Need real-time video feed from police and other emergency vehicles	45
48	Need real-time two-way data feeds for enforcement vehicles (Mobile Data Terminals)	46
60	Need collision avoidance systems	47
27	Need advance parking availability information and advanced warning of reduced roadway cross-section	48
29	Need traveler information customized to type of motorist	49
63	Need to equip commercial vehicles with more advanced in-vehicle ITS devices	50
37	Better maintenance of transit vehicles	51
53	Need better commercial vehicle weight detection and enforcement	52
47	Need mayday systems	53
34	Need web-based information for CVO, including easy access to truck restrictions information	54
50	Need to improve personal safety of drivers	55
52	Develop partnerships between CVO and law enforcement	56
54	Need quicker commercial vehicle clearing at points of entry	57
56	Need truck pre-clearance systems	58
58	Need wireless communications capability for commercial vehicles	59
62	Need in-vehicle driver monitoring systems	60
26	Too many changes in travel mode	61
61	Slow moving trucks	62
8	Provide early warning of heavy truck traffic	63
55	Need real-time commercial vehicle status information	64
51	Lack of clear policy on CVO data sharing	65
57	Need real-time vehicle location information for trucks	66

Figure 8. User Services Ranking (based on relative importance of associated needs)



Selection of Market Packages

The NIA defines the purpose of market packages as addressing specific services that might be required by traffic managers, transit operators, travelers, and other ITS stakeholders. The market packages are tightly coupled with the architecture definition and represent the building blocks that can be deployed over time to efficiently achieve high-end ITS services. Several different market packages are defined for each major application area, which provides a palette of services at varying costs.

Market packages also are identified to segregate services that are likely to encounter technical or non-technical challenges from lower risk services. For example, driver warning and vehicle control systems are defined as separate market packages due to the increased technical and non-technical risks associated with systems that dilute the driver's direct control of the vehicle. This approach yields market packages that may be deployed early with low risk. Many of the market packages are incremental so that more advanced packages can be efficiently implemented based on earlier deployment of more basic packages. In short, market packages represent ITS services and implementation options that may be considered by system implementers.

The selection of appropriate market packages is an important step in the ITS strategic planning process. Historically, market packages were introduced in the planning process, after user services that, along with functional requirements, were the last steps in the process before architecture definition. The ITS deployment guidelines have evolved to include additional steps and alternative paths for urban, regional, or Statewide ITS strategic plan developments.

The objective of this task was to identify a set of candidate market packages for potential deployment in the Triangle Region of North Carolina. The NIA provides a matrix connecting the 31 user services and the 63 market packages. This matrix allows market packages and user services to be tracked to identify specific projects and their coverage of elements in the NIA.

Table 8 illustrates the matching of the user services previously identified to the market packages. The selected market packages corresponding to the transportation needs identified by the stakeholders are indicated with a "YES". Linkages that exist, but are not applicable to the identified Triangle Region stakeholder needs are indicated with a "NO".

Note that 59 of the possible 63 market packages were identified as potentially deployable in the Triangle Region. This is due to the fact that deployment of several of the identified user services will require portions of numerous market packages. For example, the traffic control user service is matched with 11 market packages; similarly, the economic development user services are related to more than 28 market packages. While this selection may at first sight appear too broad and indiscriminate, one must keep in mind that these market packages represent sets of specific technology applications, called equipment packages, that need not all be implemented to deploy a given user service.

Table 8. Matching Market Packages to User Services Relationships

		User Services																																	
TRIANGLE		Travel And Traffic Management										Public Transportation Management					Electronic Payment		Commercial Vehicle Operations						Emergency Managemen		Advanced Vehicle Safety Systems							Information Management	Other
		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	2.1	2.2	2.3	2.4		3.1		4.1	4.2	4.3	4.4	4.5	4.6	5.1	5.2	6.1	6.2	6.3	6.4	6.5	6.6	6.7	7.1	8.1
Market Packages		Pre-trip Travel Information	En-route Driver Information	Route Guidance	Ride Matching And Reservation	Traveler Services Information	Traffic Control	Incident Management	Travel Demand Management	Emissions Testing And Mitigation	Highway-rail Intersection	Public Transportation Management	En-route Transit Information	Personalized Public Transit	Public Travel Security		Electronic Payment Services		Commercial Vehicle Electronic Clearance	Automated Roadside Safety Inspection	On-board Safety Monitoring	Commercial Vehicle Administrative Processes	Hazardous Material Incident Response	Commercial Fleet Management	Emergency Notification And Personal Security	Emergency Vehicle Management	Longitudinal Collision Avoidance	Lateral Collision Avoidance	Intersection Collision Avoidance	Vision Enhancement For Crash Avoidance	Safety Readiness	Pre-crash Restraint Deployment	Automated Vehicle Operation	Archived Data Function	Other
ad1	ITS Data Mart																																	YES	
ad2	ITS Data Warehouse																																	YES	
ad3	ITS Virtual Data Warehouse																																	YES	
apts1	Transit Vehicle Tracking											YES	YES	YES	YES																				
apts2	Transit Fixed-Route Operations											YES	YES																						
apts3	Demand Response Transit Operations											YES	YES	YES																					
apts4	Transit Passenger and Fare Management												YES				YES																		
apts5	Transit Security											YES			YES																				
apts6	Transit Maintenance											YES																							
apts7	Multi-modal Coordination						YES		YES			YES																							
apts8	Transit Traveler Information											YES	YES																						
atis1	Broadcast Traveler Information	YES	YES										YES																						
atis2	Interactive Traveler Information	YES	YES		YES	YES							YES	YES			YES																		
atis3	Autonomous Route Guidance		YES	YES																															
atis4	Dynamic Route Guidance		YES	YES		YES		YES					YES																						
atis5	ISP Based Route Guidance	YES	YES	YES													YES																		
atis6	Integrated Transportation Management/Route Guidance		YES	YES													YES																		
atis7	Yellow Pages and Reservation	YES	YES		YES	YES							YES				YES																		
atis8	Dynamic Ridesharing	YES	YES	YES	YES				YES				YES	YES			YES																		
atis9	In Vehicle Signing		YES				YES				NO																								
atms01	Network Surveillance						YES																												
atms02	Probe Surveillance						YES																												
atms03	Surface Street Control						YES	YES			NO																								
atms04	Freeway Control						YES	YES	YES																										
atms05	HOV Lane Management						YES		YES																										
atms06	Traffic Information Dissemination						YES				NO																								
atms07	Regional Traffic Control						YES																												
atms08	Incident Management System							YES																											
atms09	Traffic Forecast and Demand Management						YES		YES																										
atms10	Electronic Toll Collection																YES																		
atms11	Emissions Monitoring and Management									NO																									
atms12	Virtual TMC and Smart Probe Data		YES				YES	YES																											
atms13	Standard Railroad Grade Crossing										NO																								
atms14	Advanced Railroad Grade Crossing										NO																								
atms15	Railroad Operations Coordination										NO																								
atms16	Parking Facility Management								YES																										
atms17	Reversible Lane Management																																		
atms18	Road Weather Information System		YES				YES	YES																											
atms19	Regional Parking Management								YES																										
avss01	Vehicle Safety Monitoring																														YES	NO			
avss02	Driver Safety Monitoring																														YES				
avss03	Longitudinal Safety Warning																										YES				YES				
avss04	Lateral Safety Warning																											YES			YES				
avss05	Intersection Safety Warning										NO																		YES		YES				
avss06	Pre-Crash Restraint Deployment																														YES	NO			
avss07	Driver Visibility Improvement																													YES					
avss08	Advanced Vehicle Longitudinal Control																										YES								
avss09	Advanced Vehicle Lateral Control																											YES							
avss10	Intersection Collision Avoidance										NO																		YES						
avss11	Automated Highway System																																NO		
cvo01	Fleet Administration			YES																				YES											
cvo02	Freight Administration																						YES												
cvo03	Electronic Clearance																		YES			YES													
cvo04	CV Administrative Processes																		YES			YES													
cvo05	International Border Electronic Clearance																		YES			YES													
cvo06	Weigh-In-Motion																		YES																
cvo07	Roadside CVO Safety																			YES															
cvo08	On-board CVO Safety																				YES														
cvo09	CVO Fleet Maintenance																				YES			YES											
cvo10	HAZMAT Management							YES															YES	YES											
em1	Emergency Response																								YES	YES									
em2	Emergency Routing						YES																			YES									
em3	Mayday Support																								YES	YES									

Triangle Region ITS Architecture

The ITS architecture is a framework that describes what a system does and how it does it. The architecture identifies the functions to be performed by the system, allocates these functions to subsystems, and defines the flows of information and the interfaces between the subsystems and components. This chapter describes the process of developing the Triangle Region architecture.

The national ITS plan originally defined a series of short, medium-and long-term deployment timeframes for ITS. Several years have passed since this timeframe was developed, and the initial goal was to match schedules with the reauthorization of ISTEA. This schedule reflected FHWA's desire to implement, as quickly as possible, visible and effective ITS projects that would stimulate public support for additional funding for future deployment programs.

For the purposes of this regional ITS plan and taking into account that the ISTEA reauthorization occurred when TEA-21 was passed in 1998, the deployment timeframes for a regional implementation of selected user services are based on anticipated funding, need, and lead-time for the typical planning, design, and implementation schedules for transportation projects.

The following deployment timeframes have been identified for the Triangle Regional ITS Plan, consistent with the other regional plans in North Carolina:

Short-term	**through fiscal year 2005**
Long-term	**2006 through fiscal year 2010**

General Description of ITS Architecture

The ITS architecture is comprised of two technical layers: a transportation layer and a communications layer. The transportation layer involves the various transportation-related processing centers, distributed roadside equipment, vehicle equipment, and other equipment used by the traveler to access ITS services. The communications layer provides for the transfer of information between the transportation layer elements. The transportation and communication layers together form the *architecture framework* that coordinates overall system operation by defining interfaces between equipment that may be deployed by different procuring and operating sectors.

The transportation layer involves 19 interconnected subsystems as shown in **Figure 9**. A complete description of each subsystem, along with its architecture diagram, is provided in the national architecture documents.

In general, the communication layer consists of two components: one wireless and one wireline. The transportation layer is supported by one or both of these components. The wireline portion of the network can be manifested in many different ways, and most of them are implementation dependent.

A simplified view of the communications interface is provided in the Very Top Level Architecture Interconnect Diagram in **Figure 9**.

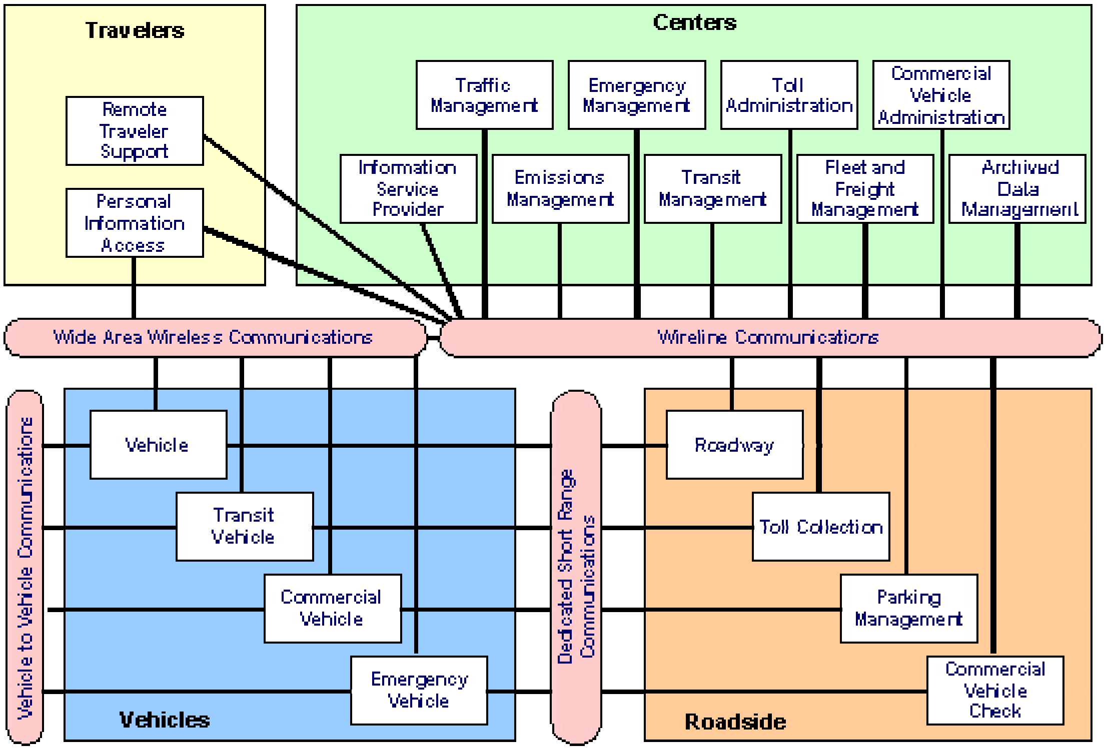


Figure 9. Top Level Architecture Interconnect Diagram.

Another element of the architecture is the institutional layer, which documents the policies, funding incentives, working arrangements, and jurisdictional structure that supports the transportation and communication layers of the architecture. The institutional layer describes who has responsibility for deploying the specific market packages and individual ITS projects and programs. It also identifies opportunities for public-public and public-private partnerships that will be necessary for successful deployment and/or operations and maintenance.

Recommended ITS Physical Architecture

The regional team facilitated market package selection. Each member of the regional team was given an opportunity to identify candidate technologies, projects, and concepts to meet the identified transportation needs. Based on this input, the regional team identified market packages for the selected user services as well as the priority in terms of short- and long-term projects. The resulting market package deployment within each of the applicable user services is summarized in **Table 9**.

S – Short-term Project/Market Package
L – Long-term Project/Market Package

Table 9. Market Package Deployment (by Timeframe)

	Market Packages	1.1 Pre-trip Travel Information	1.2 En-route Driver Information	1.3 Route Guidance	1.4 Ride Matching And Reservation	1.5 Traveler Services Information	1.6 Traffic Control	1.7 Incident Management	1.8 Travel Demand Management	1.10 Highway-rail Intersection	2.1 Public Transportation Management	2.2 En-route Transit Information	2.3 Personalized Public Transit	2.4 Public Travel Security	3.1 Electronic Payment Services	4.1 Commercial Vehicle Electronic Clearance	4.2 Automated Roadside Safety Inspection	4.3 On-board Safety Monitoring	4.4 Commercial Vehicle Administrative Processes	4.5 Hazardous Material Incident Response	4.6 Commercial Fleet Management	5.1 Emergency Notification And Personal Security	5.2 Emergency Vehicle Management	6.1 Longitudinal Collision Avoidance	6.2 Lateral Collision Avoidance	6.3 Intersection Collision Avoidance	6.4 Vision Enhancement For Crash Avoidance	6.5 Safety Readiness	7.1 Archived Data Function
ad1	ITS Data Mart																												S
ad2	ITS Data Warehouse																												S
ad3	ITS Virtual Data Warehouse																												S
apts1	Transit Vehicle Tracking										L	L	L	S															
apts2	Transit Fixed-Route Operations										S	L																	
apts3	Demand Response Transit Operations										S	L	L																
apts4	Transit Passenger and Fare Management											L			S														
apts5	Transit Security										S			L															
apts6	Transit Maintenance										S																		
apts7	Multi-modal Coordination						S		S		S																		
apts8	Transit Traveler Information										S	L																	
atis1	Broadcast Traveler Information	S	L									L																	
atis2	Interactive Traveler Information	L	L		L	L						L	L		S														
atis3	Autonomous Route Guidance		L	L																									
atis4	Dynamic Route Guidance		L	L		L		L				L																	
atis5	ISP Based Route Guidance	S	L	S											S														
atis6	Integrated Transportation Management/Route Guidance		L	L											S														
atis7	Yellow Pages and Reservation	L	L		L	L						L			S														
atis8	Dynamic Ridesharing	L	L	L	L				L			L	L		S														
atis9	In Vehicle Signing		L				L																						
atms01	Network Surveillance						S																						
atms02	Probe Surveillance						S																						
atms03	Surface Street Control						S	S																					
atms04	Freeway Control						S	S	S																				
atms05	HOV Lane Management						L		L																				
atms06	Traffic Information Dissemination						S																						
atms07	Regional Traffic Control						S																						
atms08	Incident Management System							S																					
atms09	Traffic Forecast and Demand Management						S		S																				
atms10	Electronic Toll Collection														S														
atms12	Virtual TMC and Smart Probe Data		L				L	L																					
atms14	Advanced Railroad Grade Crossing									L																			
atms15	Railroad Operations Coordination									L																			
atms16	Parking Facility Management								S																				
atms18	Road Weather Information System		L				S	S																					
atms19	Regional Parking Management								S																				
avss01	Vehicle Safety Monitoring																											S	
avss02	Driver Safety Monitoring																											S	
avss03	Longitudinal Safety Warning																							L				L	
avss04	Lateral Safety Warning																								L			L	
avss05	Intersection Safety Warning																									L		L	
avss06	Pre-Crash Restraint Deployment																											L	
avss07	Driver Visibility Improvement																										L		
avss08	Advanced Vehicle Longitudinal Control																							L					
avss09	Advanced Vehicle Lateral Control																								L				
avss10	Intersection Collision Avoidance																									L			
cvo01	Fleet Administration			S																	S								
cvo02	Freight Administration																			S									
cvo03	Electronic Clearance															S			S										
cvo04	CV Administrative Processes															S			S										
cvo05	International Border Electronic Clearance															L			L										
cvo06	Weigh-In-Motion															S													
cvo07	Roadside CVO Safety																S												
cvo08	On-board CVO Safety																	L											
cvo09	CVO Fleet Maintenance																	S			S								
cvo10	HAZMAT Management							S												S	S								
em1	Emergency Response																					S	S						
em2	Emergency Routing						S																S						
em3	Mayday Support																					L	L						

Recommended Projects and Technologies

This section summarizes the technology recommendations to support the short- and long-term deployment of ITS in the Triangle Region. These are the same deployment horizons used elsewhere in this report. The following list summarizes these technologies:

Short-term (2000 - 2005) Technologies

1. IMAP Expansion
2. Traffic signal system, including preemption and railroad crossing
3. System interconnection
4. Freeway management system expansion
5. Website of regional traveler information

Long-term (2006 - 2010) Technologies

1. Traffic signal system upgrades
2. Continued freeway management system upgrades
3. Transit Priority
4. HOV lanes
5. Kiosks
6. Ramp metering

Technologies Especially Applicable to Urban Areas

Traveler Information Kiosks – Kiosks provide users with free access at rest areas, welcome centers, etc. to a wide range of information available from state transportation agencies, tourist destinations and organizations, local governments, and downloaded information from the Web. In addition, users can check their e-mail, surf the Web, or use a search engine for a charge. Three types of kiosks have been developed for these applications: sit-down, stand-up, or stand-alone countertop unit. Some of these units are designed to supplement traveler counselors available at most state welcome centers (Source: Arizona DOT).

World Wide Web – The Web provides access to a universe of information, some of which (weather, road closures, etc.) can be downloaded from other sites. Applications are for users prior to departure, although en-route information can be provided at kiosks in welcome centers.

In-vehicle Automatic Vehicle Location (AVL) System – Integrated units featuring a global positioning satellites (GPS) receiver, cellular digital packet data (CDPD) modem, processor, keypad, display and sensor interface are available. Some units are designed to interface to vehicle sensors and controls such as road temperature, material spreaders via standard RS-232/RS-485 interface, and can detect plow or sweeper up/down status. Functions include operator log-on, vehicle position and transmitting, emergency alarms, two-way messaging, and sensor data collection and storage. (Source: Orbital Sciences Corp., Germantown, Maryland.)

Vehicle Tracking and Information System Software - These systems are integrated with the in-vehicle device referenced above, and include the mapping, messaging, reporting, playback and vehicle information functions. Reporting takes place through an open database connectivity (ODBC) compliant database, and information includes such data as total operating miles, deadhead miles, material spread (maintenance vehicles), road temperatures, etc. (Source: Orbital Sciences Corp., Germantown, Maryland.)

Traffic Sensing System – Magneto-inductive sensors are installed in the pavement and transduce small magnetic charges into inductive charges. These charges permit data collection for monitoring traffic. These systems consist of sensors, sensing electronics, cabling, and installation components. They support traffic data collection and storage to monitor speed, number of vehicles by classification, lane occupancy, and vehicle length. (Source: 3M Safety and Security Systems Division.)

Surveillance and Delay Advisory System (SDAS) - The SDAS consists of three data collection technologies: WIM, video-based sensing, and spot speed measurements. The system gathers data from a construction zone (the area around a special venue such as a tourist destination), computes travel times and delays through the zone of interest, and transmits delay messages to motorists traveling through the zone. (Source: Office of Safety Research and Development, FHWA, McLean, Virginia.)

DMS - Special attention for use of DMS in urban areas include traffic congestion advisories, tourist information, and various events - such as duration, size, and severity.

Description of Strategic Plan Projects

This Triangle Regional ITS Strategic Plan has identified the needs of the Triangle Region's transportation stakeholders and has matched them, where possible, to one or more ITS market packages, each representing an ITS solution. Of the 63 market packages currently defined in the NIA, 59 were identified as suitable for deployment in the region. By identifying the desired implementation horizon for each of the 59 selected market packages, technology deployment phasing was developed. The recommended ITS solutions were once again cross-checked against the identified user needs, resulting in a more complete set of recommendations.

This section lists the technologies that should be deployed to achieve the desired functionality of each selected market package. The project title, description, and estimated cost of each deployment is listed. In addition, the schematic diagram of the existing, planned, and programmed ITS deployments in the region has been modified to show the proposed short- and long-term proposed deployments. This modified schematic is shown in **Figure 10**.

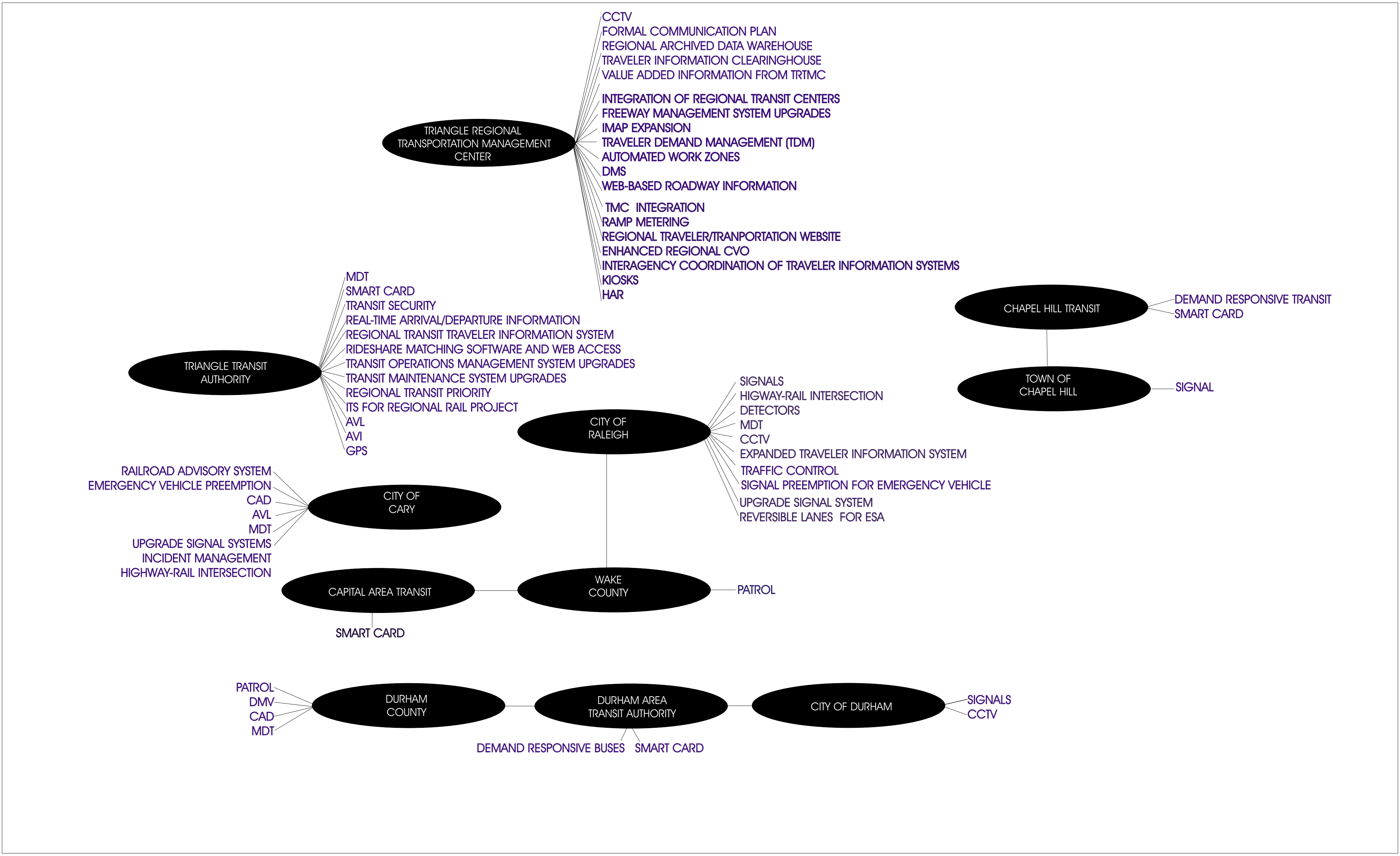


FIGURE 10 - SHORT AND LONG TERM ITS DEPLOYMENTS IN THE TRIANGLE

Kimley-Horn and Associates, Inc.

Short-Term Projects

The following projects are recommended for short-term deployment in the Triangle Region. The projects are grouped according to systems. All costs shown are assuming year 2000 dollars.

Freeway/Incident/Event Management

Freeway Management System Upgrades. The three NCDOT divisions within the Triangle Region currently operate and maintain many miles of freeway. This system will be expanded over the short-term timeframe, as follows:

- US 64 from Apex to Knightdale – adding six cameras and three DMS
- NC 55 from Apex (US 1) to Durham – adding three cameras
- NC 147 along its entire length – adding three cameras and two DMS
- US 15-501 from Durham through Chapel Hill – adding one camera and three DMS
- I-440 along its entire length – adding 20 miles of detection, seven cameras and seven DMS
- I-40 throughout the region – adding 20 miles of additional detection, five cameras and five DMS to the existing deployment
- I-540 on completed sections – installing detection, cameras, and DMS

These corridors will be outfitted with fiber optic communications along their routes, tying the entire system together to the Triangle Regional Transportation Management Center (TRTMC), which will be provided with expanded capabilities to facilitate the addition of the new devices. The anticipated cost for this expansion is $28,000,000.

IMAP Expansion. The IMAP program has been successful throughout the state of North Carolina and especially in the Triangle Region. The program will be expanded in the Triangle Region by adding three new vehicles and extending the hours of operation. Due to the cost of the new vehicles, the initial cost will be approximately $500,000. However, the success of the IMAP program depends on the ongoing maintenance and support and the salaries necessary for the expanded hours and additional drivers. The ongoing costs are expected to increase by approximately $250,000 per year over the current cost.

Ramp Metering. Ramp metering is an effective method of improving freeway operations by limiting access to individual vehicles, as opposed to groups or platoons of vehicles. In addition, ramp metering can be used to limit or significantly reduce freeway access as threshold or critical volumes are reached, in order to prevent recurrent congestion. The sites for the proposed ramp meter installations have not yet been selected; however, the following corridors are being considered:

- I-40 – Four locations
- I-440 – Four locations
- I-540 – Two locations

The anticipated cost for the deployment of these 10 ramp meter locations is $2,500,000.

TRTMC Interconnection. The existing TRTMC is not connected to, and therefore cannot share data and video with, many of the regional traffic management systems. NCDOT is currently planning to design and install permanent connections, via the internet, of the following centers: City of Raleigh signal system, City of Durham signal system, various emergency management centers, highway patrol dispatch, various transit centers, and other traffic management centers in the state. This interconnection will be primarily through the internet. However, many of the planned and proposed deployments have the necessary communications infrastructure to deploy a regional interconnection that will provide sufficient bandwidth to share multiple full motion video channels. The internet-style system currently is being deployed by NCDOT; therefore, there are no costs associated directly with this task.

Formal Communications Plan. A formal communication plan is needed in the Triangle Region to assist in tying together the communications throughout the region. This deployment plan provides a brief overview of the communications network that is necessary for the region. A more formal study, however, is necessary for several reasons. First, it will determine the exact bandwidth necessary between centers and from individual devices to hubs or concentration points. Second, it will fully document the fiber availability along corridors. Third, it will make recommendations on how to best to use this fiber, including technology choices. Lastly, it will provide an overall, consistent design standard that all of the agencies throughout the region can use as the system expands.

For instance, the three NCDOT divisions that make up the Triangle Region currently have some level of communication. If, however, the Town of Cary desires to share data and video with NCDOT, the lack of a standard communication network may make this impossible. Additionally, documenting specifically what each agency needs to actively participate will enable each agency to budget the necessary resources, both in terms of dollars and people. Finally, by settling on a standard communication framework and device throughout the region, it should be possible to leverage the buying power through the region to get lower prices on end equipment, and a regional maintenance contract, as opposed to expensive training of personnel at each agency.

The development of this plan is anticipated to cost $500,000.

Operations and Maintenance Plan. As a short term goal NCDOT should develop an operations and maintenance plan consistent with the goals of the ITS Architecture. The operations and maintenance plan should be phased across the long and short term goals to provide a detailed scope of existing and future needs. The cost to develop this plan will be internal to NCDOT.

Travel Demand Management (TDM). NCDOT is currently working with businesses in the Research Triangle Park (RTP) to implement TDM. TDM consists of reducing peak hour commuters by varying work arrival and departure times and offering telecommuting or other methods to reduce the travel demand on the network. NCDOT currently is offering many employees in the Triangle Region the opportunity to work at home on a part-time basis. Although there is no direct cost to NCDOT associated with this project, there is the potential for better implementation by offering incentives to companies and through a more focused marketing and outreach campaign to document the effort and the potential benefits. The incentives and outreach campaign can all be performed by NCDOT employees at no direct cost.

Traffic Control

Town of Cary Signal System. The Town of Cary will deploy a traffic signal system that features communication between the signals and a central location. There currently is no coordinated signal system in Cary, with the exception of part of Harrison Avenue. The Cary system will permit upload and download capabilities and, possibly, advanced abilities such as traffic adaptive and responsive capabilities. The Town of Cary will install a citywide signal system, which features a fiber optic communications network. This system is anticipated to provide significant travel time savings. There is currently a feasibility study underway to document these expectations. Final design is expected in early 2002. The anticipated cost of the signal system is $7,000,000.

Town of Cary Railroad Advisory System. The Town of Cary will deploy a railroad grade advisory system similar to the system in Rocky Mount. This system will notify the central signal system that the crossing arms are down. From the central control center, emergency dispatchers can be notified about which route to use. This anticipated cost of the railroad advisory system is $125,000.

Town of Cary Emergency Vehicle Preemption. One of the issues identified through the stakeholders involvement process is the need to improve the response time for emergency vehicles to reach the scene of an incident as well as to return to the hospital or emergency room. Many local agencies have already installed 3M Opticom® equipment in the area, and all new emergency vehicle preemption equipment will be the same. Emergency vehicle preemption equipment will be installed at 50 intersections in Cary. The anticipated cost of this project is $140,000.

Transit

Smart Card Technology. There are numerous existing or planned regional bus systems within the region. Once transfer hubs for the regional bus systems are developed, a regional electronic payment system (Smart Card) will be implemented that permits the same method of payment for all transit systems in the region. In addition to permitting travelers to use multiple bus systems without a complicated payment system, Smart Cards allow the various transit and planning agencies to better track ridership, transfers, and other information that can be used in the planning for future transit enhancements. The anticipated project cost is $500,000.

Bus Arrival Vehicle Information System. The bus system in the region is currently outfitted with AVL devices. The location of buses within the system, however, is not being relayed to travelers, notifying them of arrival times at key locations. Software that uses the information from the AVL devices to predict arrival times at certain locations will be purchased/developed/ modified. These locations will be outfitted with a display that informs travelers of the projected bus arrival time. This system will ultimately cover the entire Triangle Region if the demonstration project proves successful. The demonstration project is anticipated to cost $250,000.

Regional Transit Traveler Information System. There are currently three local transit systems, two university transit systems, and one regional transit system, as well as various county human services transportation providers. As this region grows, more jurisdictions will likely begin some type of transit operations. Today, each agency has independent systems for providing transit traveler information regarding their own services. A regional system would enable users to go to a single source for all transit information.

The Regional Transit Traveler Information Center would have 10 staffed customer information stations, each with its own computer providing static information on schedules, transfers, and fares; dynamic trip itinerary planning, including immediate geographic recognition of the callers location; and eventually real-time bus arrival information. The estimated costs of this project are $400,000 in capital costs for startup and $600,000 for annual operations. Implementation of this project is scheduled for 2003.

By 2005, the Triangle Transit Authority (TTA) plans to provide direct web access to transit trip itinerary planning. The upgrade of systems from the customer information desktop computer to the internet is estimated to cost an additional $200,000.

Transit Security. The TTA is building a new Regional Transit Center in RTP and a new Park & Ride facility in downtown Durham. Each of these facilities - as well as TTA's Bus Operations and Maintenance Facility-will need a video surveillance system to ensure the safety and security of passengers and employees. The required equipment will include video cameras, monitors, recording equipment, and a communications system to enable remote-monitoring. The estimated cost is $150,000 to be implemented with construction of the facilities by 2003.

Rideshare Matching Software and Web Access. The TTA's Rideshare Program plans to purchase state-of-the-art rideshare matching software and to provide customers with direct access to it through TTA's website. This service was an identified need by the RTP's Transportation Demand Management Committee, and will provide a much higher quality service to all TTA's rideshare customers. TTA intends to have this software installed and operational by 2001. The estimated cost for this project is $150,000.

Transit Operations Management System Upgrades. The TTA will need to upgrade internal data and software systems to automate the additional functions of operations, planning, and management. This includes upgrades to existing servers and the purchase of new proxy internet and database servers, the development of an intranet, network-based postage meter, and upgrades to frame-relay circuits, routers. TTA intends to upgrade its transit operations management systems over the years 2001 through 2005 at a projected cost of $300,000.

Transit Maintenance System Upgrades. The TTA plans to acquire equipment to provide advanced maintenance functions. The equipment would include desktops and laptops for mechanics to conduct on-board diagnostics, recording vital operational and maintenance data that is used to automatically generate preventative maintenance schedules, vehicle service histories, and support other maintenance activities. This project will require the purchase of two laptop computers and two desktops and the installation of wireless communications for the maintenance facility. The project is anticipated to cost $15,000 and be implemented by 2001.

Traveler Information

Regional Traveler/Transportation Website. NCDOT will develop a website or series of pages at an existing website to provide static travel information. This information may include transit schedules, fares and routes, published road closures, traffic policies, major generator and special event information, rideshare matching information, and links to other city and NCDOT websites. The costs for this project are being borne internally by NCDOT for various ITS web development projects. Development beyond the basic linking of sites may require additional financial resources.

Web-Based Roadway Information. As mentioned previously, NCDOT is in the process of developing a web-based, real-time regional roadway information system to inform motorists of short-and long-term road closures. This project will all be done within NCDOT so all of the costs are internal to NCDOT.

Interagency Coordination of Traveler Information. NCDOT is in the process of developing a method of sharing and coordinating traveler information throughout the Triangle Region. For the purposes of the short-term (five year horizon), this coordination will occur via telephone and low bandwidth communications. Higher speed communication will be used as the regional communication network is developed.

Most of this project involves interagency coordination, that is identifying the data and information that is valuable to share and developing a coordinated response plan. These costs are all being borne internally by NCDOT.

CVO

Commercial Vehicle Information Systems and Networks (CVISN). CVISN is the use of ITS information system elements that support CVO, including a network of information systems owned and operated by governments, carriers, and other stakeholders. The goal of the CVISN process is to use information technologies and networks to transfer credentials concerning commercial vehicles to reduce the time and energy costs typically associated with this process. NCDOT has been actively working to implement CVISN statewide. This includes enforcement and electronic credentials. Some of the projects that are currently underway within the CVISN and ITS/CVO programs include:

Web Credentials. NCDOT is preparing electronic credentials on the web for commercial vehicle operators. Part of the site is already operational; however, the electronic credentials are still under development. This project is being done internally to NCDOT so there are no development costs.

Truck Presence Detection. NCDOT presently is implementing an automated system in the Charlotte area to identify trucks on alternate routes that are using those alternate routes to bypass weigh and inspection stations.

Mobile Inspection. NCDOT and the Department of Revenue are deploying a fleet of vehicles that can check credentials and perform truck inspections remotely throughout the Charlotte area. This fleet, called Wolf Packs, will be used to identify non-compliant trucks and trucks that are using alternate routes to avoid weigh and inspection stations.

WIM Sites. NCDOT will implement WIM sites throughout the region to verify truck weights. This program will begin with a demonstration project to determine the effectiveness of these sites in to catching cheaters. This demonstration project will cost approximately $200,000.

Safety

Automated Work Zones. NCDOT is purchasing equipment that provides worker safety in work zones. This equipment consists of standard off-the-shelf packages that feature portable speed and classification detection, speed warning signs, communication (via cellular telephone or radio) to alert police of speeders in a work zone, and, possibly, automatic enforcement measures.

Long-term Projects

Freeway/Incident/Event Management

Freeway Management System Upgrades. The three NCDOT divisions within the Triangle Region currently operate and maintain many miles of freeway. This system will be expanded over the long-term timeframe as follows:

- NC 54 from Raleigh to Chapel Hill – two cameras
- US 70 from Raleigh to Durham – two cameras and two DMS
- I-85 Through Durham, north – four cameras and three DMS
- I-540 Outerloop – 12 miles of detection, four cameras and two DMS

These corridors will be outfitted with fiber optic communications along their routes, tying the entire system together to the TRTMC, which will be provided with expanded capabilities to facilitate the addition of the new devices. The anticipated cost for this expansion is $15,000,000.

TRTMC Integration. The short- and long-term freeway management system expansions will provide the backbone necessary to share data and video throughout the region. Once communications are established, a formal integration effort is required to provide users with a common platform from which to view, operate, and/or maintain all the traffic and transit systems within the region. The following centers will be integrated: City of Raleigh signal system, City of Durham signal system, various emergency management centers, highway patrol dispatch, various transit centers, and other traffic management centers in the state. This system is being developed internally by NCDOT. The costs associated with this project already have been identified in the statewide plans.

Traffic Control

Upgrade Raleigh Signal System. The City of Raleigh will upgrade its existing signal system and replace it with a state-of-the-art system. The new system will facilitate daily operations, including up- and downloading data and timing plans, as well as traffic adaptive abilities. This upgrade will include upgrading the communication network and selected controllers and cabinets. In addition, Advanced Traffic Management Systems (ATMS) elements, such as lane control signals, DMS, and CCTV will be included. This system also will be designed and acquired with the intent of full compatibility with the TRTMC. This upgrade is anticipated to cost approximately $10,000,000.

Regional Emergency Vehicle Preemption. One of the issues identified through the stakeholder involvement process is the need to improve the response time for emergency vehicles to reach the scene of an incident as well as to return to the hospital or emergency room. Many local agencies have already installed 3M Opticom® equipment in the area, and all new emergency vehicle preemption equipment will be the same. Emergency vehicle preemption equipment will be installed at 500 intersections throughout the region, with 250 additional emitters being purchased and installed. The anticipated cost of this project is $875,000.

Transit Systems

Regional Transit Priority. There is an important need to save time for transit passengers along key transit corridors and throughout the Triangle Region. A transit priority system for buses throughout the region will be deployed. This system will use the same receivers as the emergency vehicle preemption system. The hardware for this system will cost approximately $330,000. Implementation will be the responsibility of each agency.

In addition to the hardware, a regional study is required to identify key corridors and intersections where transit priority would provide the greatest benefit. At locations where it is identified that transit priority will provide a benefit, the signals must be reviewed for timing and operations to determine the appropriate priority treatment. Additionally, the timing modifications need to be prepared for each location to ensure each agency implements transit priority according to plan. This study and all of the signal modification plans are anticipated to cost $400,000.

Real-time Arrival/Departure Information. This project will feature video and audio displays at major stops/stations and transit centers, individual access via the Internet, phone, cell phone, pager, cable TV, and personal digital assistants. In addition it will be integrated with on-board video and audio displays, and stop annunciator ("Talking Bus"). The equipment and software needed to implement this project are estimated to cost $1,000,000.

ITS for Regional Rail Project. Over the next 10 years, the first phase of the TTA's regional rail plan will be constructed and in operation. As part of the construction of this project, various ITS elements will be required to manage rail transit operations, safety and security, and passenger information. These elements include fiber-optic and radio communication backbones along the rail corridor; CCTV cameras and monitors to record stations and grade-crossings, wayside telephones, and passenger information systems at stations. The total estimated cost for these projects is $5,000,000.

Additional ITS equipment-such as on-board passenger information systems, railroad coordinated train control at-grade crossing, railroad preemption equipment for street intersections and grade-crossings, real-time online train schedules and arrival information-will cost an additional $2,000,000.

Traveler Information

Traveler Information Clearinghouse. A clearinghouse will be established to store real-time data for traveler information. This system will feature data from system loops, intersections, detector stations, posted incident reports, IMAP incident reports, and real-time bus schedule information. All this information whether it is stored locally or remotely will be accessible from a central location. The development of this clearinghouse will be used in kiosks and websites, with the development geared for long-term projects, such as a voice activated system. The anticipated cost of this system is $250,000.

Regional Archived Data Warehouse. ITS data collection components provide a significant amount of information that can be used in the long-term planning process, as well as for various optimization routines and strategies. The data collected through the ITS elements will be collected/warehoused in a database for future use in these processes. All data from the region will be available at one central location for future use and reference. The anticipated cost of this system is $100,000.

Value-Added Information from the TRTMC. There are many private companies that are beginning to repackage ITS data to provide to customers, as described later in this report. NCDOT will investigate opportunities to sell or provide this information to these companies. This effort will require little effort from the Department, aside from identifying potential partners and preparing legal documents relating to the partnership. Data messaging and other efforts required to convert information into a format compatible with the needs of the private partner will be the responsibility of the partner. All of the costs associated with this project are internal to NCDOT.

Kiosks at Major Public Venues. NCDOT and the cities in the Triangle Region will develop and install 10 kiosks that use web-based technologies to link to the websites in the area that display local traffic and event information. In addition, these kiosks will display information of interest for tourists, including destinations, lodging, restaurants, and information centers. Potential locations include regional malls, rest areas, visitors' bureaus, chambers of commerce, arenas and coliseums, hotels, racetracks, convention centers, and others.

Kiosks provide NCDOT with the opportunity to enter into ventures with private entities in two ways. The first is by selling or leasing kiosks at locations that are not public facilities, including large employers, malls, or hotels. In addition, if additional kiosks are requested at locations, they also may be sold or leased. The second opportunity is to permit the generation of kiosk operating revenue by either selling, advertising, or licensing the kiosks. This would enable NCDOT to recover some of the costs of providing the data and hosting websites.

The cost of installing 10 kiosks throughout the Triangle Region is approximately $600,000. There are additional costs associated with the long-term operations of kiosks, especially as more are added, for updating information and adding bandwidth.

The development costs of the kiosk content needs to be shared among the many interested parties. Traffic and transit data is only a small portion of the information that is available, and is typically the least used. The most used information is concerning local interests and directions to destinations. Therefore, the development costs of the content needs to be borne by those who will benefit the most: tourist destinations, restaurants, and hotels.

Expand the Traveler Information System. The traveler information systems identified as a short-term project limits the user input to selecting bus routes and identifying "hot spots" along major routes. As a long-term project, NCDOT will expand the system to provide additional real-time information, such as transit arrival, estimated travel times and video images from the Triangle Region. The expansion of this system, with regard to integration and web site development (including hardware), is estimated to cost $1,500,000.

Project Summary

A summary of the aforementioned projects and their estimated cost are shown in **Table 10**.

Table 10. Summary of ITS Projects and Estimated Costs (based on year 2000 dollars).

Short-Term Projects			Long-Term Projects		
Description		**Cost ($000)**	**Description**		**Cost ($000)**
Freeway/Incident Management			**Freeway/Incident Management**		
S-1	Expansion of the TRTMC	28,000	L-1	Expansion of the TRTMC	15,000
S-2	Ramp Metering on I-40, I-440, I-540	2,500	L-2	Interconnection (integrated software) of TMC to other centers	**
S-3	Operations and Maintenance Plan	200			
S-4	IMAP Expansion	500			
S-5	Expansion of IMAP Patrols	495			
S-6	Travel Demand Management (TMD)	**			
S-7	Communications Plan	500			
S-8	Interconnection (via the internet) of TMC to other centers	**			
Subtotal		$32,195	**Subtotal**		$ 15,000
ATMS			**ATMS**		
S-9	Signal System Town of Cary	7,000	L-3	Upgrade Raleigh Signal System	10,000
S-10	Town of Cary Railroad Grade Crossing Advisory System	125	L-4	Signal Preemption for Emergency Services	875
S-11	Town of Cary Emergency Vehicle Preemption	140			
Subtotal		$7,265	**Subtotal**		$10,875
APTS			**APTS**		
S-12	SmartCard Payment System	500	L-5	Signal Priority for Transit	730
S-13	Bus Arrival Information System	250	L-6	ITS for Light Rail	1,000
Subtotal		$750	**Subtotal**		$1,730
ATIS			**ATIS**		
S-14	Interagency Coordination of Traveler Information	***	L-7	Traveler Information Clearinghouse	250
S-15	Web-Based Roadway Information	***	L-8	Regional Archived Data Warehouse	100
S-16	Regional Traveler / Transportation Website	***	L-9	Value Added Information from TRTMC	***
			L-10	Expand the Traveler Information System	1,500
			L-11	Kiosks at Major Public Venues	600
Subtotal		$0	**Subtotal**		$2,450
CVO					
S-17	Web Credentials	***			
S-18	Truck Presence Detection				
S-19	Weigh in Motion (WIM) Sites	200			
S-20	Mobile Inspection				
Subtotal		$200			
Safety					
S-21	Automated Work Zones	***			
Subtotal		$0			
Total Short-Term		$40,410	**Total Long-Term**		$30,055
Total 20-year Estimated Costs			**$ 70,465,000**		
**No direct costs					
***Costs are borne internally by NCDOT					

Operational Concepts

A primary objective with ITS deployments is to provide operational coordination across jurisdictional lines. The proposed Triangle Regional plan will do this by actively sharing data and video and permitting all of the individual deployments to work in concert with one another in the event of a major regional incident. During normal conditions, however, each agency in the region needs to take operational responsibility for their own system.

During major incidents or special events, however, the impacts extend beyond individual jurisdictions and into the entire region. During these major events, regional control and traffic management is a primary concern. The operators within the TRTMC will be trained to respond to incidents and operate the systems around the region.

Following the development of this deployment plan, a regional operations plan that ties in operating procedures for systems throughout the region needs to be developed. This plan will include an incident management plan, with set responses for incidents throughout the region, procedures on working with various emergency personnel, and directions on how to work with the many different traffic management and signal systems in the region. The agencies in the Triangle Region, and their primary responsibilities are as follows:

NCDOT – Statewide
- Proposed center on Wade Avenue
- Integrate with Raleigh signal system
- Combine with management center on Blue Ridge Road and take over responsibilities

State Highway Patrol
- Emergency management
- Enforcement
- Incident management

Division of Motor Vehicles
- Weigh station
- Incident management

NCDOT Division 4 – Triangle Region
- IMAP, CCTV, reversible lanes, etc.
- Regional Traveler Information – website development, kiosk traffic information, etc.
- HAR
- Major event/incident coordination

NCDOT Division 5 – Triangle Region
- IMAP, CCTV, reversible lanes, etc.
- Regional traveler information – website development, kiosk traffic information, etc.
- HAR
- Major event/incident coordination

NCDOT Division 7 – Triangle Region
- IMAP, CCTV, reversible lanes, etc.
- Regional traveler information – website development, kiosk traffic information, etc.
- HAR
- Major event/incident coordination

City of Raleigh
- City of Raleigh traffic signal control/systems

- City of Raleigh proposed coordination with statewide center
- City of Raleigh traveler information – local issues and attractions, local traffic information, etc.

City of Raleigh Police Department (PD)
- City of Raleigh emergency management
- City of Raleigh enforcement
- City of Raleigh incident management

Wake County Sheriff
- Wake County enforcement
- Wake County safety management

Wake County Emergency Medical Service (EMS)
- Wake County emergency management
- Wake County enforcement
- Wake County incident management

Town of Chapel Hill
- Town of Chapel Hill traffic signal control/systems

Town of Chapel Hill PD
- Town of Chapel Hill emergency management
- Town of Chapel Hill enforcement
- Town of Chapel Hill incident management

Orange County
- Orange County enforcement
- Orange County incident management

Orange County Sheriff
- Orange County enforcement
- Orange County safety management

Orange County EMS
- Orange County emergency management
- Orange County enforcement
- Orange County incident management

City of Durham
- City of Durham traffic signal control/systems

City of Durham PD
- City of Durham emergency management
- City of Durham enforcement
- City of Durham incident management

Durham County Sheriff
- Durham County incident management
- Durham County emergency management
- Durham County enforcement

Durham County EMS
- Durham County emergency management

Town of Cary PD
- Town of Cary emergency management
- Town of Cary enforcement
- Town of Cary incident management

City of Apex PD
- City of Apex emergency management
- City of Apex enforcement
- City of Apex incident management

Benefits of ITS Systems

The benefits of ITS deployment are difficult to measure by simple quantitative analysis. An integrated ITS deployment program can include safety improvements, delay reduction, cost savings, capacity improvements, customer satisfaction, energy consumption reduction, and positive environment impacts. Municipalities throughout the United States are already seeing benefits from existing deployments. This benefit analysis reviews the existing deployments for various short and long term projects recommended for the Triangle Region and provides real-world examples of benefits being realized by other municipalities. Quantifiable benefits for air quality monitoring can be obtained by following the Federal Highway Administration August 1999 report *Off-Model Air Quality Analysis – A Compendium of Practice* which is included in the Appendix. The following examples illustrate true potential application of the Triangle Region ITS deployment plan.

Freeway/Incident/Event Management

There are three major ITS functions that make up Freeway Management Systems (FMS). These include monitoring and controlling freeway operations and providing current traffic information to motorist. The most common ITS devices used for monitoring and control include camera surveillance and ramp metering. Where variable message signs, updated web sites and highway advisory radio are commonly used to provide traffic information to the motorist. A traffic management center (TMC), the control center for the various ITS deployments, is responsible for monitoring freeway conditions and dispersing the information to motorist. Although FMS are most effective when used in conjunction with incident management and transit management systems, when used by themselves, they can make a substantial difference in increasing average speeds, reducing travel time, minimizing stop delays and reducing accident rates.

IMAP

The Incident Management Assistance Patrol are emergency traffic patrol vehicles equipped to aid minor breakdowns, push or tow vehicles, and reposition and move trailers. The purpose of this program is to respond as quickly as possible to debilitated vehicles to minimize the impact on traffic flow. When additional equipment is added such as computer aided dispatch systems, global positioning systems and mobile changeable message signs, patrols can get the job done faster. Programs like these also benefit the environment by restoring traffic flow and minimizing idling vehicle emissions. Additionally, this program provides an added measure of safety and security to the public.

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice included in the appendix of this report for analyzing air pollution reduction with incident management.

Ramp Metering

Ramp meters, an integral ITS deployment used in freeway management systems, have proven to be a valuable tool in controlling traffic while improving flow rates, reducing travel times, emissions and fuel consumption. They also improve the safety of merging traffic while reducing accidents.

A good example of benefits obtained from ramp metering is demonstrated by the collection of data obtained from TMCs around the country for various ramp metering deployments. Survey results demonstrated that ramp meters have increased average speeds between 16% and 62% while reducing travel time by an average of 48%. Also, the data shows TMC's increased throughput between 8% to 22% while demand increased by 17% to 25%. With the increase in demand, the ramp meters have successfully reduced accidents by 15% and 50%[3]. Below are specific examples of ITS benefits from successful nationwide FMS deployments.

- Portland, Oregon: 58 ramp meters, 43% accident reduction, 39% travel time reduction, 25% demand increase, 60% increase in speed.
- Minneapolis/St. Paul, MN: 6 ramp meters, 5 miles of instrumented freeway, 24% accident reduction, 38% accident rate reduction, 16% increase in speed.
- Seattle. WA: 22 ramp meters, 52% decrease in travel time, 39% decrease in accident rate, 86% increase in demand.
- Denver, CO: 5 ramp meters, 50% accident reduction, 18.5% demand increase.
- Detroit, MI: 28 ramp meters, 50% accident reduction, 8% increase in speed, 12.5% increase in demand.
- Austin, TX: 3 ramp meters, 2.6 miles of instrumented freeway, 60% increase in speed, 7.9% increase in demand.
- Long Island, NY: 70 ramp meters, 128 miles of instrumented freeway, 15% accident reduction, 9% increase in speed.

Ramp metering alone has shown to produce a favorable benefit cost ratio. In Minneapolis, an evaluation of the ramp metering deployments showed that benefits of $40 million compared to total costs to implement ramp metering at $2.6 million, yielded a benefit cost ratio of 15:1[4].

Implementing a FMS has also proven to be more cost effective in improving freeway operations than widening the freeway. As an approximate comparison, freeway widening costs $2 million per lane-mile while a complete implementation FMS of an urban corridor costs $500,000 per freeway mile plus the cost

[3] Robinson, J. and Piotrowicz., "Ramp Metering Status in North America, 1995 Update," Federal Highway Administration, June 1995

[4] SRF Consulting Group, Inc., N.K. Friedrichs Consulting, Inc. "Twin Cities Ramp Meter Evaluation," Minnesota Department of Transportation, February 2001.

of a freeway management center[5]. This amounts to approximately 2:1 benefit cost ratio not including costs for the TMS. Moreover, if the existing freeway is four lanes, implementing a FMS could add about half the capacity of an additional lane at about 1/8 the cost of adding a lane.

For more information on emissions analysis for ramp metering refer to the Off-Model Air Quality Analysis: A Compendium of Practice, Federal Highway Administration Region Four, September 1997 included in the appendix of this report.

Traffic Control

Traffic signals that are interconnected and include traffic adaptive and responsive capabilities have proven to improve traffic progression and reduce delays. Additionally, the interconnection of signals working together has high environmental benefits in the reduction of fuel consumption and emissions. These benefits are illustrated by the examples below:

A Texas state program called the Traffic Light Synchronization (TLS) involved the installation of a system which tied each signal within the system together using communication interconnect with a modem link back to a shop computer. The system has resulted in benefits shown below with an estimated benefit/cost ratio of 62:1.[6]

TLS Summary:

Travel Time	13.8%	decrease
Travel Speed	22.2%	increase
Delay	37.1%	decrease
Fuel Consumption	5.5%	decrease
CO Emissions	12.6%	decrease
HC Emissions	9.8%	decrease

Another example that demonstrates the effectiveness of interconnected signals, is the city of Toronto's evaluation of the SCOOT signal control system. This system is comprised of 75 signals and is installed on two corridors and the central business district. The evaluation showed a decrease in both travel time and vehicle stops by 8% and 22%, respectively, and a reduction in delay by 17%. Moreover, due to the

[5]"Comparison of Conceptual System Design and Costs: ITS Surveillance and Communication Applications: Rural vs Urban Freeway Corridors," prepared by Edwards and Kelsy for the I-95 Corridor Coalition, September 1995.

[6] Benefits of the Texas Traffic Light Synchronization Grant Program I, TxDOT/TTI Report #0258-1, Texas DOT, Austin,

improved traffic flow, fuel consumption was reduced by 6%, carbon monoxide (CO) emissions by 5% and hydrocarbon (HC) emissions by 4%.[7]

For methodologies on analyzing emissions reduction, refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report.

Town of Cary Railroad Advisory System

Railroad advisory systems communicate with traffic signals when the crossing arms are activated. This allows for traffic signals to adjust their timing so that traffic proceeding towards the railroad crossing can be slowed down or possibly rerouted by the traffic control center. This advisory system is beneficial to the environment because when traffic signals adjust their timing, the traffic flow is maintained at such a rate to minimize vehicle stops and thus promote less vehicle emission. Moreover, if traffic flow is rerouted, then traffic can continue to flow at an efficient rate and minimize vehicle stops. These system also pay for themselves in the cost of human lives by allowing emergency services to respond to incident faster by avoiding areas where a route may be blocked by a crossing train.

Town of Cary Emergency Vehicle Preemption

Emergency vehicle preemption works with traffic signal systems by alerting the signals of their oncoming presence up to a half-mile away. Traffic signals can then adjust their timing and allow emergency vehicles to proceed through an intersection with little delay. This system greatly reduces the chances of a collision at an intersection that in return saves costs in both emergency vehicle replacements and the legal liability when a motorist is injured. In addition, emergency vehicle preemption allows emergency vehicles to reach their destination faster which can make a difference between life and death in many emergency situations. This system works in concert with a well timed signal system to provide priority for emergency services while having minimal impact on other traffic.

Transit

Smart Card Technology

Smart Card Technology is a form of electronic payment that permits the same method of payment for all public transit systems. Through a computerized system, the smart card has the ability to track the fare accounts and demands of its riders as well as their respective travel patterns. Information obtained from the smart card system such as route, time or type of fare can be used to modify and/or expand transit routes based on user habits. In addition, this system improves the accuracy and reduces the costs for data collection when research is needed. The use of the Smart Card promotes traveler convenience that

[7] Glassco, R., "Potential Benefits of Advanced Traffic Management Systems," The MITRE Corporation, ITS-L-141, November, 1995.

also encourages increased use of the public transit systems. Smart Card technology is most effective when used in conjunction with AVL devices and bus arrival systems.

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

Bus Arrival Information System

The bus arrival information system, a component of the transit management system, and used in conjunction with the Automatic Vehicle Location (AVL) device, will display information to passengers about arrival times for key locations. This service combined with the AVL system and smart card technology will provide a powerful and efficient transit management system.

The implementation of a complete Transit Management System has shown to increase ridership and reduce costs for transit operators. For example, Winston-Salem, North Carolina evaluated a computer aided dispatch and scheduling system on a 17 bus fleet. Within six months the ridership grew from 1,000 to 2,000 users and vehicle miles per passenger-trip grew 5%. Moreover, operator expenses dropped 2% per passenger trip and there was a decrease in passenger wait time by 50%.[8]

Transit management systems also provide more efficiency for transit operations and may enable transit operators to streamline operations. Kansas City, Missouri was able to reduce 10% of the equipment required for some bus routes by using AVL/CAD while maintaining customer service. In addition, the use of an AVL system allowed Kansas City to eliminate seven buses out of a 200 bus fleet, thus allowing Kansas City to recover its investment in the AVL system within two years.[9]

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

Transit Security

Providing security on transit systems, passenger stations and park-ride-lots in the form of video surveillance, recording equipment and a communications system would promote a feeling of safety for travelers and reduce crime related incidents. An investment in security will likely encourage greater faith in the transit system and may contribute to greater ridership from the public.

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

[8] Stone, J., "Winston-Salem Mobility Management: An Example of APTS Benefits, "NC State University, 1995.
[9] Giugno, M., Milwaukee County Transit System, July 1995 Status Report.

Rideshare Matching Software and Web Access

A ridesharing program through access on the Web would provide travelers an easy way to find carpool candidates. The encouragement of ridesharing could impact traffic congestion and air pollution if single occupancy trips were reduced.

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for the Dade County Florida Vanpool methodology.

Transit Priority

The transit priority allows for special treatment to transit vehicles at signalized intersections on roads with significant transit use. Three types of priority strategies exist. The first type of priority is the passive priority strategy that incorporates the timing of coordinated signals at the average bus speed instead of the average vehicle speed. The second type of priority is the active priority strategy that involves signals detecting the presence of a transit vehicle and thereby granting an early green signal or holding a green signal that is already displayed. The third priority strategy involves a short stretch of bus lane at the intersection called the queue jump lane. This enables buses to by-pass waiting queues of traffic and to cut out in front by receiving an early “bus only” green signal. By including at least one or all of the priority strategies, the average travel time per transit route can be reduced substantially.

The success of this type of program is demonstrated by two cities already employing priority strategies. Los Angeles has incorporated the signal priority on two routes called the Metro Rapid along the Whittier-Wilshire Boulevard and Ventura Boulevard. Total travel time for each Metro Rapid route has dropped by 25% compared to regular local service. Vancouver , Canada introduced the 99 B-line rapid bus along a 11mile cross town route with 14 stops. Travel times for this route were reduced by 20-40% compared to the local bus travel times. This program was successful enough to add a second rapid bus route in September of 2000.[10]

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

Traveler Information

Web/Roadway Traveler Information System

Providing traveler information over several modes of travel can be beneficial to both traveler and service providers. Several transit agencies as well as some Traffic Management Centers have started using kiosks, local cable television and web sites to disperse information about current traffic conditions and transit schedules. This enables travelers to make more informed decisions for trip departures, routes and

[10] Bus Rapid Transit Web Site, brt.volpe.dot.gov/guide/signal.html, February 14, 2001.

modes of travel. They have been shown to increase transit usage, and may help reduce congestion when travelers select alternate routes or postpone trips.

An example of how effective the traveler information system can be is illustrated by the surveys performed in the Seattle, Washington and the Boston, Massachusetts areas. These surveys indicated that when provided with traveler information, 30%-40% of travelers adjusted their travel. Of those that changed their travel, 45% of travelers changed their route of travel and 45% changed their time of travel, while the remaining 10% changed their mode of travel.

Traveling information systems are believed to greatly impact vehicle emissions as well. In 1999, it was projected that 96,000 callers would use the SmarTraveler system in Boston on a daily basis . To estimate the impact the SmarTraveler system would have on emissions, the MOBILE5a model was used but included only 30% of the projected 96,000 daily callers. The results from the model concluded that on a daily basis there would be an average reduction by 25% of volatile organic compounds, as well as 1.5% of NO_x and 33% of CO as compared to daily vehicle emissions not influenced by the SmarTraveler system[11].

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for methodologies of calculating the effects of transit improvements on air pollution.

Other ITS Benefits

Arterial Management Systems

Arterial Management systems are used to manage the traffic and control of arterial roadways through signal coordination, surveillance, sign control, and motorist informational systems. Traffic management centers also play an important role in these systems by monitoring and controlling traffic conditions and dispersing information to motorist about the arterial roadways. There have been numerous evaluations on the arterial management systems operating in cities around the world that have determined that these systems produce substantial environmental benefits by reducing vehicle stops, which then creates a reduction in fuel consumption and vehicle emissions. Additionally, arterial management systems have improved methods for reducing incident delays, increasing average speeds, as well as lowering accident rates. Arterial management systems are most effective when used in conjunction with incident management and transit management systems. Moreover, when multiple operational components are implemented such as surveillance, motorist informational systems as well signal coordination, a traffic management center has greater adaptive capabilities and control to improve changing traffic conditions.

A good example of how arterial management systems can substantially improve traffic conditions is demonstrated by a 1994 evaluation of a computerized signal control in the City of Los Angeles. This system had been in operation since 1984 and as of 1994 it was comprised of 1,170 intersections and 4509 detectors for signal timing optimization. The results of this evaluation reported a 13% decrease in

[11] Tech Environmental, Inc., Air Quality Benefit Study of the SmarTraveler Advanced Traveler Information Service, July 1993.

vehicle stops, 18% reduction in travel time, 16% in average speed, 13% decrease in fuel consumption and 14% decrease in emissions.[12]

There are many different types of ITS devices that produce successful arterial management systems. In Fairfax City, Virginia a program was started that used automated cameras to record violations and ticket violators in an effort to reduce intersection accidents. It was reported that after the program was implemented there was a 35% reduction of accidents at intersections with traffic lights. Arterial management systems can increase overall capacity of existing roadways, increase road safety for motorist and improve the environment at a justifiable cost.

Refer to the Off-Model Air Quality Analysis: A Compendium of Practice provided in the appendix of this report for methodologies of calculating the effects of signal improvements on air pollution.

Lane Control and Reversible Lanes

Lane Control utilizes various forms of dynamic message signs and specific lane control signs to convey directional, speed regulatory, warning and travel information to freeway users. There are several ways lane controls can be used. One example of lane control is when a reversible lane is used to convey high traffic volumes for each approach. The lane control signs, which are usually displayed well in advance of a merge, are used to close a lane on whichever approach has the lower volume during a given time period and keeps all lanes open for the higher volume approach. Additionally, lane control displays are used to convey messages of speed control for particular lanes due to accidents, weather conditions, construction or special events. Lane control is beneficial because it can decrease traffic congestion and reduce vehicle delays. Moreover, with a reduction in idling vehicles, lane control will also help to reduce air polluting vehicle emissions. Another Lane control benefit is the reduction in vehicular accidents. In England, a system incorporating lane control paid for itself within a year based solely on accident reductions[13].

[12] City of Los Angeles Department of Transportation, "Automated Traffic Surveillance and Control (ATSAC) Evaluation Study," June 1994.
[13] Freeway Lane Control, www.bts.gov/ntl/99030/s03/body_s03.html, accessed 2/28/01

National Architecture Compliance

The development of the short- and long-term projects is the final step before the development of the regional architecture. The regional architecture that is used is a derivative of the national architecture as previously discussed. However, the regional architecture includes multiple figures and tables that document the relationships between various components, control centers, and agencies. The regional architecture documentation and all associated figures are provided as a supplement to this report.[14]

The intent of the regional architecture is to document the flows of data between the many elements that are currently and will ultimately be deployed throughout the Triangle Region. Based on the regional architecture, as individual projects are developed, they can be incorporated to ensure that information is shared throughout the region.

The architecture database that has been prepared for this report is not intended to sit on a shelf. Rather, it is intended to be a living database that is updated as projects are deployed or new projects are planned.

Standards

In additional to compliance with the National Architecture, USDOT has been working with the industry to develop standards for use within the ITS community. The most common standard that has been deployed to date is the National Transportation Communication for ITS Protocol (NTCIP) for traffic signals. As of 1999, NTCIP was the only widely adopted standard. However, there are many more that are being developed and approved nationally for use in ITS. The standards identified for the Metrolina region have been identified through the use of Turbo Architecture[15]. The standards that have been identified are:

Relevant Standards Activities

AASHTO	NTCIP - Application Profile for File Transfer Protocol (FTP)	2303
AASHTO	NTCIP - Application Profile for Trivial File Transfer Protocol	2302
AASHTO	NTCIP - Applications Profile for Data Exchange ASN.1 (DATEX)	2304
AASHTO	NTCIP - Base Standard: Octet Encoding Rules (OER)	1102
AASHTO	NTCIP - Subnetwork Profile for Ethernet	2104
AASHTO	NTCIP - Subnetwork Profile for Point-to-Point Protocol using RS 232	2103
AASHTO	NTCIP Guide	9001
AASHTO	NTCIP - Object Definitions for Video Switches	1208
AASHTO	NTCIP - Simple Transportation Management Protocol (STMP)	1103
AASHTO	NTCIP - Profiles - Framework and Classification of Profiles	8003
AASHTO	NTCIP - Ramp Meter Controller Objects	1207

[14] The architecture was developed using Turbo Architecture 2000 version 1.0, developed by FHWA.
[15] This list has been complied from the output produced from the Turbo Architecture tool.

AASHTO	NTCIP - Data Dictionary for Closed Circuit Television (CCTV)	1205
AASHTO	NTCIP - Object Definitions for Environmental Sensor Stations & Roadside Weather Information System	1204
AASHTO	NTCIP - Applications Profile for Common Object Request Broker Architecture (CORBA)	2305
ASTM	Standard Specification for DSRC - Physical Layer 902-928 MHz	PS 111-98
ASTM	Standard Specification for DSRC - Data Link Layer	Draft Z7633Z
EIA/CEA	Data Radio Channel (DARC) System	EIA-794
EIA/CEA	Subcarrier Traffic Information Channel (STIC) System	EIA-795
ANSI	Commercial Vehicle Safety Reports	TS284
ANSI	Commercial Vehicle Safety and Credentials Information Exchange	TS285
ANSI	Commercial Vehicle Credentials	TS286
IEEE	Standard for Common Incident Management Message Sets (IMMS) for use by EMSs	P1512
ITE	Advanced Traffic Controller (ATC) Application Program Interface (API)	9603-1
ITE	ATC Cabinet	9603-2
ITE	Advanced Transportation Controller (ATC)	9603-3
ITE	Message Set for External TMC Communication (MS/ETMCC)	TM 2.01
ITE	Standard for Functional Level Traffic Management Data Dictionary (TMDD)	TM 1.03
IEEE	Survey of Communications Technologies	ITSPP#5
IEEE	ITS Data Dictionaries Guidelines	ITSPP#6A
AASHTO	NTCIP - Simple Transportation Management Framework (STMF)	1101
AASHTO	NTCIP - Class B Profile	2001
AASHTO	NTCIP - Global Object Definitions	1201
AASHTO	NTCIP - Object Definitions for Actuated Traffic Signal Controller Units	1202
AASHTO	NTCIP - Object Definitions for DMS	1203
AASHTO	NTCIP - Point to Multi-Point Protocol Using RS-232 Subnetwork Profile	2101
IEEE	Guide for Microwave Communications System Development	1404
IEEE	Recommended Practice for the Selection and Installation of Fiber Optic Cable	P1454
IEEE	Message Sets for DSRC ETTM & CVO	1455
IEEE	Standard for Message Set Template for ITS	P1488
IEEE	Standard for Data Dictionaries for ITS	1489
AASHTO	NTCIP - Transportation System Sensor Objects	1209
AASHTO	NTCIP - Data Collection & Monitoring Devices	1206
AASHTO	NTCIP - Application Profile for Simple Transportation Management Framework (STMF)	2301
AASHTO	NTCIP - Internet (TCP/IP and UDP/IP) Transport Profile	2202
SAE	Truth-in-Labeling Standard for Navigation Map Databases	J1663
SAE	Serial Data Comm. Between MicroComputer Systems in Heavy-Duty Vehicle Applications	J1708
SAE	Information Report on ITS Terms and Definitions	J1761
SAE	A Conceptual ITS Architecture: An ATIS Perspective	J1763
SAE	ISP-Vehicle Location Referencing Message Profiles	J1746
SAE	In-Vehicle Navigation System Communication Device Message Set Information Report	J2256
SAE	On-Board Land Vehicle Mayday Reporting Interface	J2313
SAE	Mayday Industry Survey Information Report	J2352
SAE	Information System (ATIS) Data Dictionary	J2353
SAE	Advanced Traveler Information System (ATIS) Message Set	J2354

SAE	ITS Data Bus Architecture Reference Model Information Report	J2355
SAE	Standard for Navigation and Route Guidance Function Accessibility While Driving	J2364
SAE	ITS Data Bus Protocol - Link Layer Recommended Practice	J2366-2
SAE	ITS Data Bus Gateway Recommended Practice	J2367
SAE	ITS Data Bus Conformance Test Procedure	J2368
SAE	Standard for ATIS Message Sets Delivered Over Bandwidth Restricted Media	J2369
SAE	Field Test Analysis Information Report	J2372
SAE	Stakeholders Workshop Information Report	J2373
SAE	National Location Referencing Information Report	J2374
SAE	ITS In-Vehicle Message Priority	J2395
SAE	Measurement of Driver Visual Behavior Using Video Based Methods (Def. & Meas.)	J2396
SAE	Adaptive Cruise Control: Operating Characteristics and User Interface	J2399
SAE	Forward Collision Warning: Operating Characteristics and User Interface	J2400
SAE	ITS Data Bus Data Security Services Recommended Practice	J1760
SAE	ITS Data Bus Protocol - Physical Layer Recommended Practice	J2366-1
SAE	ITS Data Bus Protocol - Thin Transport Layer Recommended Practice	J2366-4
SAE	ITS Data Bus Protocol - Application Layer Recommended Practice	J2366-7
ITE	TCIP - Control Center (CC) Business Area Standard	1407
ITE	TCIP - Common Public Transportation (CPT) Business Area Standard	1401
ITE	TCIP - Fare Collection (FC) Business Area Standard	1408
ITE	TCIP - Framework Document	1400
ITE	TCIP - Incident Management (IM) Business Area Standard	1402
ITE	TCIP - Onboard (OB) Business Area Standard	1406
ITE	TCIP - Passenger Information (PI) Business Area Standard	1403
ITE	TCIP - Scheduling/Runcutting (SCH) Business Area Standard	1404
ITE	TCIP - Spatial Representation (SP) Business Area Standard	1405
ITE	TCIP - Traffic Management (TM) Business Area Standard	TS 3.TM

The first priority with the continued deployment in the Triangle Region is to comply with national standards. However, a number of choices were made in the development and deployment of the TRTMC and other systems over the past few years that will affect the standards that are chosen. An example is emergency vehicle preemption. To date, all of the deployments for emergency vehicle preemption have used 3M Opticom® equipment. This system uses a proprietary interface that is not standard. To change this to an open standard driven system would require that all of the existing Opticom® equipment either be replaced or upgraded (if possible). This is not feasible. In instances such as this, the existing system will be maintained.

Regional Communication Architecture

Based on the short- and long-term projects, the key component of the Triangle Region's ITS deployment plan is a dynamic traveler information system that will enable travelers to access road conditions both before leaving and while on the road. This system will require a virtual regional database of traffic conditions and traveler information from which the users can obtain the information they require. This regional system, with the various inputs and outputs, is shown in **Figure 11.**

The concept of the architecture is that all the agencies and traffic operation centers both regionally and, to some extent, statewide will provide information that can be easily accessed from one concise front end. There are two options to operate a regional traveler information system: central and virtual. These two concepts are shown in **Figure 12**. NCDOT has the foundation for either type of system in place with ncsmartlink.org operating in both modes. This is known as a hybrid system.

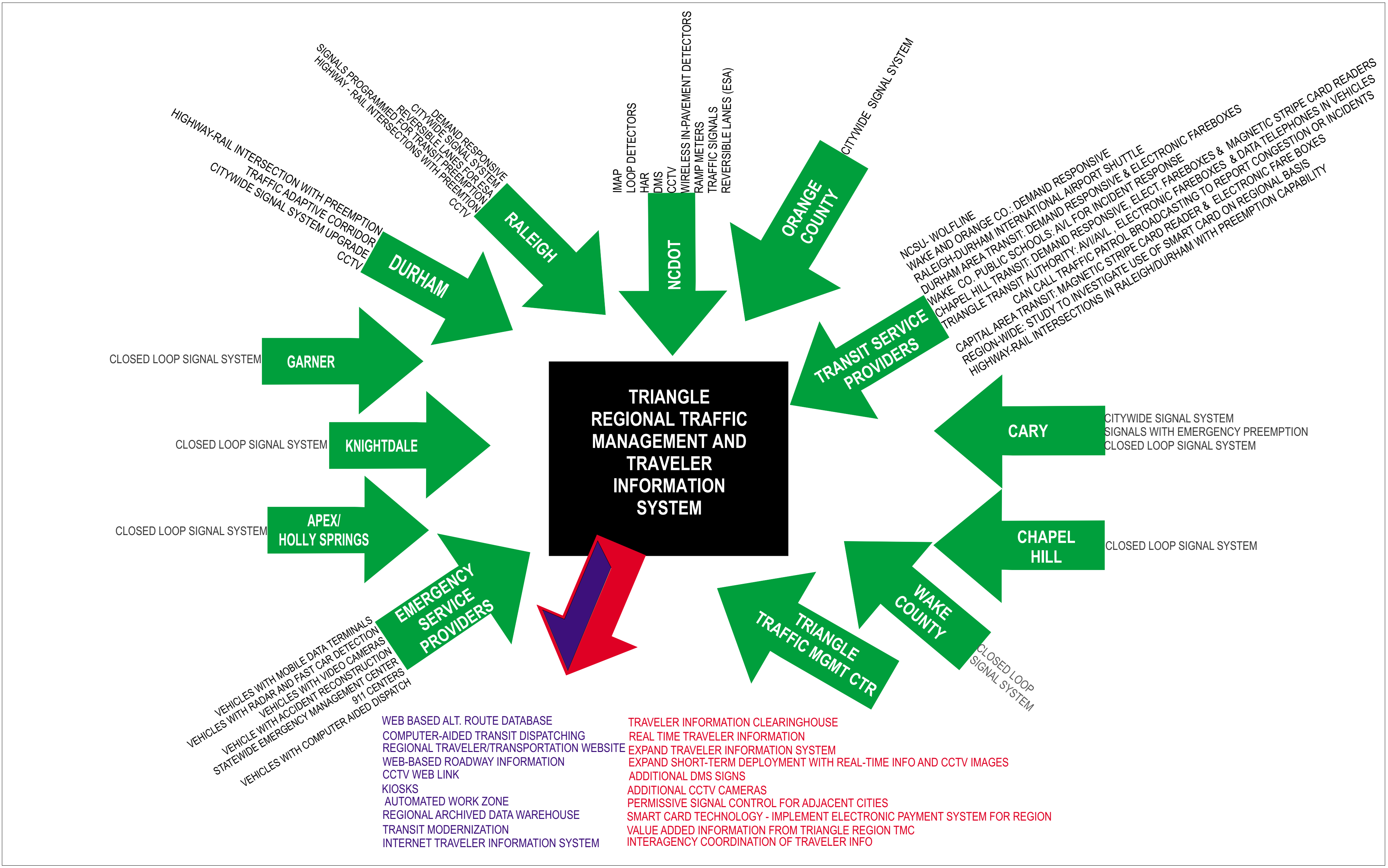


Figure 11 Generic Regional Architecture

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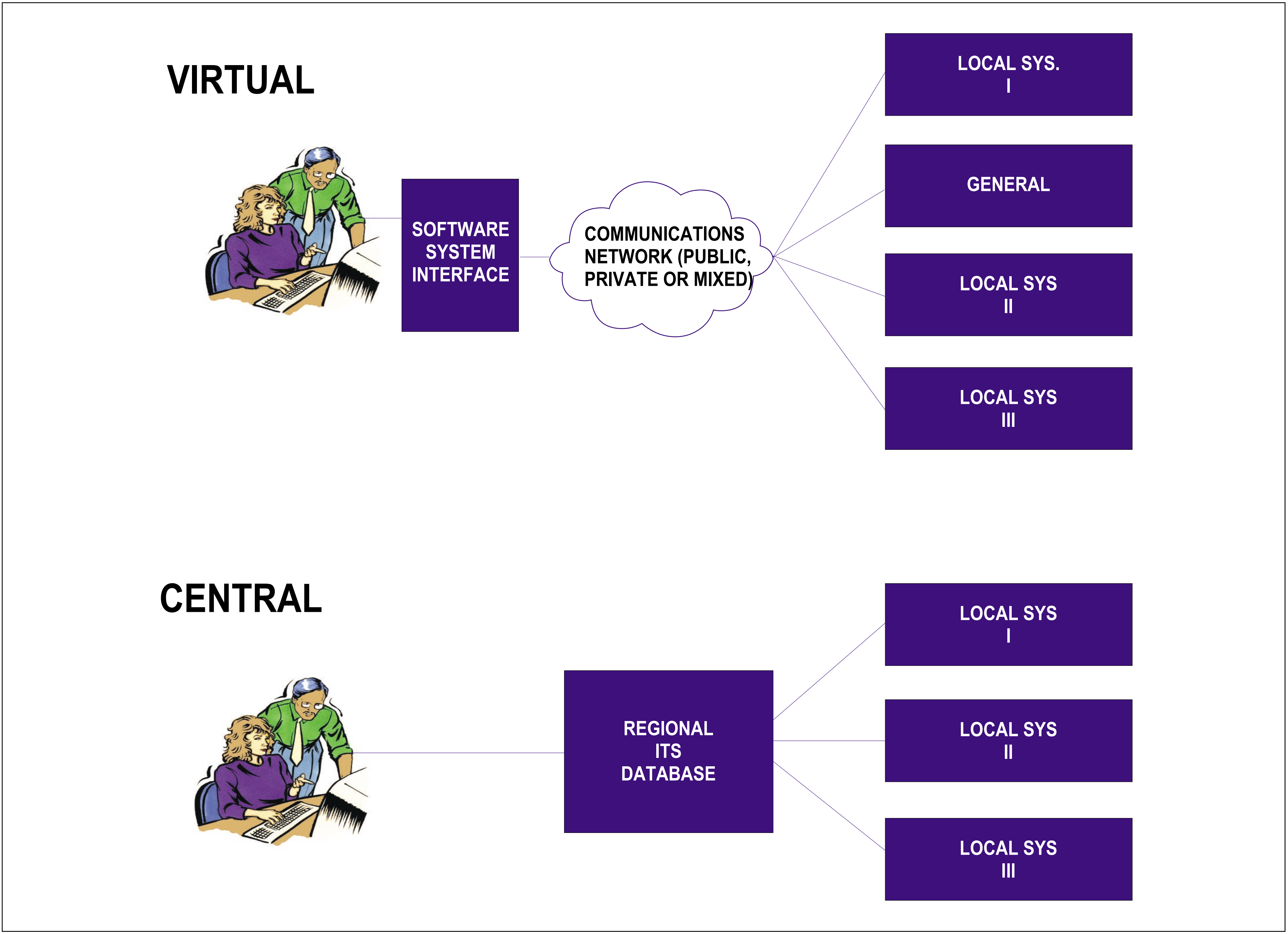

Figure 12 Central vs. Virtual Information System

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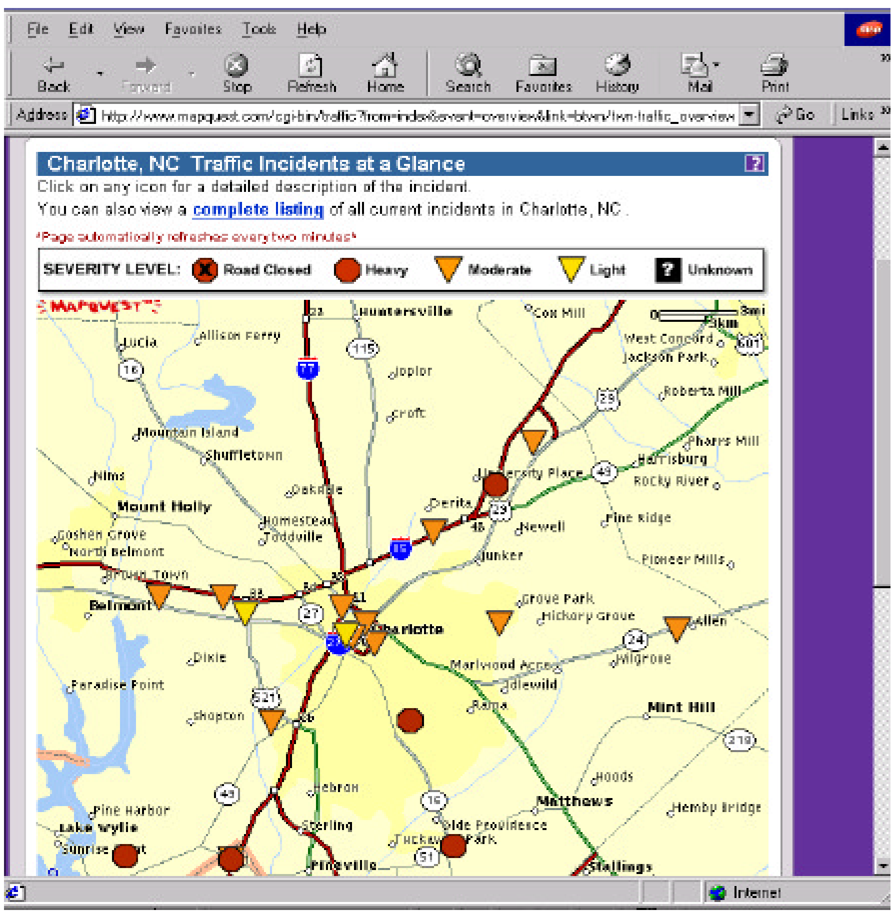
Central Information System

A central system is the more expensive of the two to design, build, operate, and maintain. A central system requires that all the data, video, and other information be brought to one central location for dissemination. For instance, the TRTMC could house the information system. This system would store all of the information, both data and video, and disseminate it as needed. A type of central system is provided by MapQuest at www.mapquest.com. MapQuest's traveler information pages get data from the DOT and provide it on the MapQuest. A sample image from MapQuest is provided for the Charlotte areas (Triangle area in development) in **Figure 13**.[16]

MapQuest is a sample of a third party using available information to document and present traffic conditions in real time. Other web sites with similar information include www.smartroutes.com, www.strategy.com (in development), and others.

Figure 13. Sample MapQuest Image.



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16 MapQuest is just one of many private sector companies repackaging ITS information for profit. Others include Yahoo! (traffic.yahoo.com),SmartRoutes (www.smartroutes.com) and TrafficStation (www.trafficstation.com).

The advantage of a central system is that is provides consistency to the end user in both the look and feel, and also in the data and video provided. A central system provides greater control over the information, in that one agency, organization, or even person has the ultimate responsibility for all of the system's components.

The key disadvantage is the cost needed to design, construct, operate and maintain such a system. Where a virtual system would require that the end user have an adequate connection to the regional and local sites, the central system requires that there be a permanent connection from the central system to each of the local sites. In essence, the responsibility of data and video dissemination falls on whoever is operating the central system.

Virtual Information System

A virtual information system requires less front-end expense than the central system, but also has issues with compatibility and consistency. A virtual system provides a front-end for the user from which he or she can select the information that is desired. When selected, however, the user connects directly to the local system from which information is requested. The only information stored at the central location is the front-end and generic regional information. All of the specific data and video can be accessed from each of the local sites.

The advantage of a virtual system is that it provides the same information as a central system, but at a lower front cost. The only requirement for the virtual system is a link from the central system to each of the local systems. The bandwidth for the local systems to transmit this information to the end user is the responsibility of the local agencies. A virtual system is very similar to the World Wide Web. A site like yahoo.com provides traffic and traveler information through links to the various sites. This is similar to a virtual system.

The key disadvantage of the virtual system is the consistency amongst the sites, both in terms of look and feel, as well as status. Different internet sites have different methods of presenting information. Unlike a central system where one person or group has control of the look of a site, a virtual system has different groups of people responsible for each of the local sites, which can confuse users. This problem can be eliminated by standardizing the front ends of the various systems.

It is important that the status of the varying sites be consistent. Where the central system has all of the data and information stored and processed locally, the virtual system relies on other sites to be operational, up to date, and consistent. If it is not, users will stop visiting the site for traffic and traveler information.

Regional Architecture Recommendation

The Triangle Region is a developing region with respect to ITS and traveler information systems. Because of the maturity associated with parts of the ITS deployment, a full central system is not appropriate. Likewise, due to the negative aspects associated with the virtual system, a virtual system is not recommended. Rather, a hybrid system is proposed. This recommendation not only covers the traveler information system elements, but also the day-to-day control and monitoring.

A hybrid system is proposed because the necessities of day-to-day operation will require that a significant portion of the infrastructure necessary be in place, namely a communication ring around the Triangle Region. The hybrid system will maintain the independence of the existing transportation management centers within the region, however will provide links to and from each of the centers to promote information sharing. In addition, data of regional importance will be stored and disseminated in a regional traveler information clearinghouse.

The hybrid system will include a central TRTMC. However, this center will only have primary responsibility for the NCDOT deployed and maintained elements. Each municipality within the region will have responsibility for their own individual elements, such as signal systems and the regional transit system. All of the centers responsible for controlling the various elements will be tied together through a regional system as described below. This regional system will permit the sharing of data and video to all of the connected agencies.

Communication System

The Triangle Regional communication system requires that data and video be shared amongst several municipalities and three NCDOT Divisions (4, 5 and 7). The two options for this system are a Star type topology and a full ring network. A star topology would involve a connection between the two NCDOT facilities, with the two facilities serving as hubs for the local agencies. The ring topology would require that each major facility, both city and state, be connected on a ring through the entire region.

A star topology is recommended. A small bandwidth connection between the Triangle Region Transportation Management Center and each of the smaller division centers is necessary to share information between the central control center and each of the regions. Each of the local agencies will also have a connection, as it is necessary to transmit the required information.

The primary advantage of this type of a system for the Triangle Region is its ability to conform to the needs of each agency as well as to grow over time. This provides for the most economical solution for the region in terms of initial cost. Where the ring network would require a direct connection of the same size bandwidth to each agency, the star network allows each link to be sized according to need.

As the ITS infrastructure continues to grow with new development and highway construction throughout the region, it may be possible to convert the star topology into a fully redundant ring network. Since it is unlikely that the infrastructure will be ready within the 10 year deployment timeframe, the star topology is defined and described in this report.

Communications Assessment

The primary communication link is between the field devices and the TRTMC. All of the NCDOT data and video will be concentrated into and disseminated from this central point.

The secondary communication link is between the TRTMC and each of the NCDOT Division offices (4, 5 and 7). This link needs to be able to transmit low frame rate video and data from each direction between the centers. As communications infrastructure is installed throughout the region, the connections to Divisions 4 and 5 should be made to increase the available bandwidth. Additionally, the statewide report will document the needs and functionality of the connection to Division 7.

Video images can be broadcast or transmitted at different data rates, depending on the quality desired by the viewer. The higher the data rate, the better the quality. As data rates decrease, images tend to become either smaller or jumpy. It is recommended that, for center-to-center video, a data rate of between 3 and 6 Mbs be used. This rate will allow full frame, full motion video with little or no “jumping.”

Video between the TRTMC and the division centers to cities and other agencies may vary, depending on the available bandwidth, and expanded as the communication infrastructure increases. For the purposes of traffic control video, a low data rate of 1.5 Mbs is reasonable since it can be transmitted over one leased T-1 line. The video transceivers and multiplexers available today allow the data rate to be changed so, as different communication options become available, the only changes necessary in the end equipment will be in the software needed to convert the data rate and in the network interface to change connection types.

Data transmission of traffic information requires substantially less bandwidth than video transmission. Typical data from a traffic signal system is constant, but not at a high data rate (most controllers are limited to data rates as low as 14.4 or 28.8 Kbs. Data from other sources, such as traffic data count stations, DMS, and HAR does not require continuous communications; rather, the data (or voice for HAR) is sent in a burst. The more bandwidth available, the shorter the burst.

Data transmission between local agencies and the NCDOT TRTMC can be accommodated either by a direct connection or through leased communications using Digital Subscriber Line (DSL), Integrated Services Digital Network (ISDN), or a leased T-1. This type of continuous communication will permit information to be shared with the central control centers and these centers sharing the information with other users, as necessary.

Communications Plan

The proposed communications plan for the Triangle Region is shown in **Figure 14**. This figure represents the number of video images being simultaneously transmitted over a link at any given time. It also shows the bandwidth required for data and video transmission.

Most of the required communication links already exist, have been designed, or are under construction. Most of the trunk line connecting Raleigh, Durham, and Chapel Hill has been completed, is under construction, is being designed, or is in the initial planning stages. The links that remain are tying the local municipalities into the main trunk line.

It is recommended that NCDOT be responsible for the operations and maintenance of the regional communication network. The annual operations and maintenance budget for the regional system, (fiber only), is anticipated to cost $150,000. If not already purchased, fiber test and maintenance/repair equipment needs to be purchased at an approximate cost of $150,000.

The costs identified at each municipality are for the purchase and installation of the necessary end equipment at each location. A match to each of these devices is required at the TRTMC.

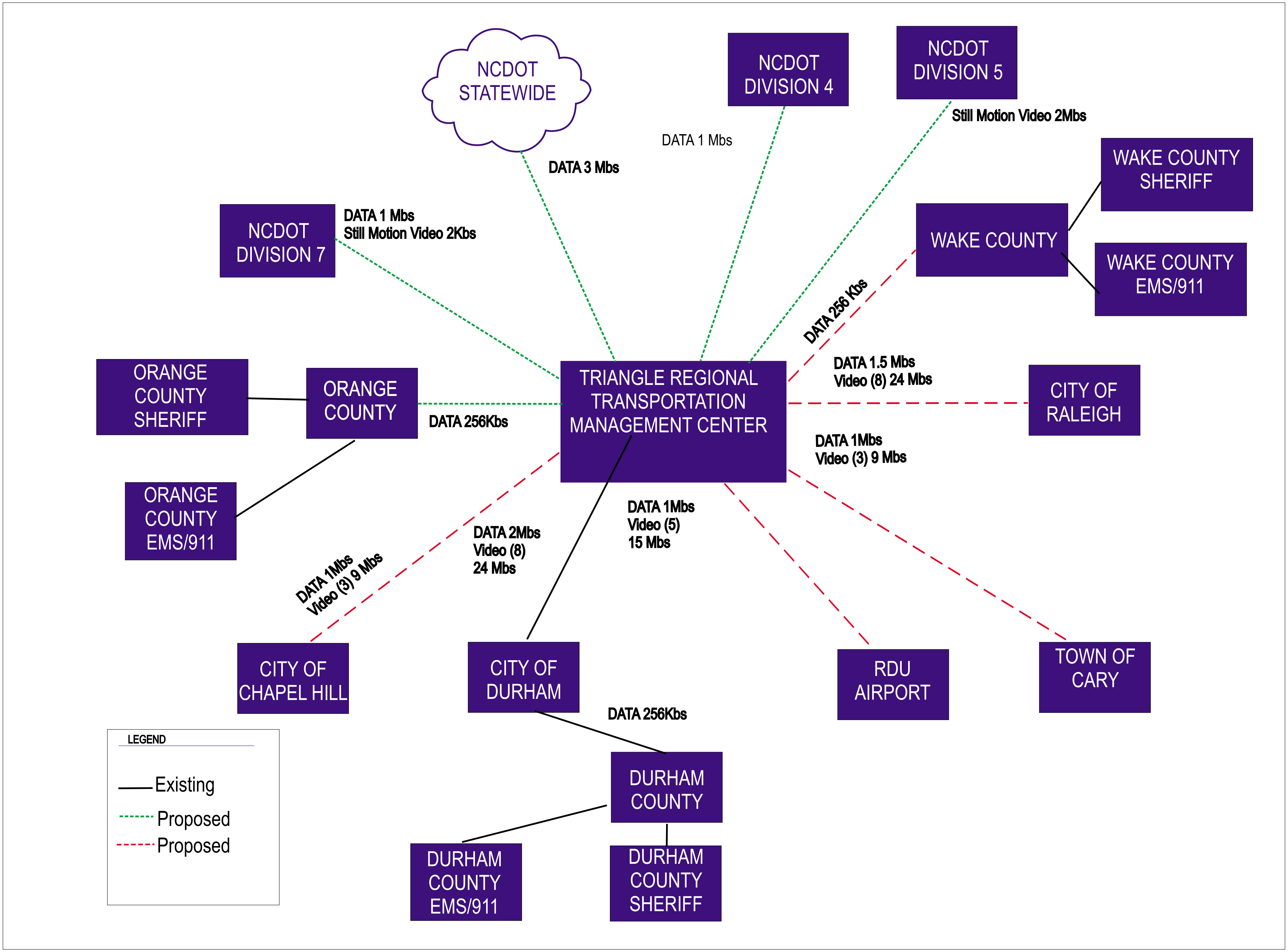

Figure 14 Triangle Region Communications Plan

Kimley-Horn and Associates, Inc.

Formal Communication Plan

The purpose of this document is to outline an overall ITS plan for the Triangle Region. The regional communication architecture and this communication plan are intended as a guide for further development. It is vital that a formal, coordinated, regionally developed and approved communication plan be prepared. This plan needs to document, in specific terms, the fiber optic backbone and spurs, down to the fiber number (tube and fiber color). In addition, a specific network architecture (SONET, ATM, proprietary) needs to be identified and agreed upon, in addition to video transmission standards (MPEG 1, 2, MJPEG, etc.) and methods (point-to-point, broadcast, etc.).

By making these decisions as a region, each agency can begin to plan to purchase the required end equipment that is necessary to create compatible system that enables the entire region to share data and video seamlessly. In addition, this plan will permit the region to hire the personnel required to operate and maintain the high-end electronics necessary to operate the communication system as opposed to making one or two people from each agency responsible for their own maintenance, with little training or experience.

Durham Connection

The City of Durham already has a significant fiber infrastructure throughout the city. This fiber meets the NCDOT fiber at numerous locations. The connection of the City to the NCDOT fiber will require end equipment and splicing. End equipment in Durham is expected to cost $100,000 - with annual maintenance and operations costing approximately $10,000.

Raleigh Connection

The City of Raleigh, as part of the long-term package, is intending to purchase and install an upgraded traffic signal system. Part of this signal system will be upgraded communications, likely in the form of fiber optics. However, to integrate Raleigh into the TRTMC, a connection is required between the TRTMC and the City. A bandwidth of approximately 25.5 Mbs is required.

It is recommended that a fiber optic connection be installed between the TRTMC and the City of Raleigh. This will require approximately two miles of fiber in an urban setting. Conduit and fiber optic cable installed in this region will cost approximately $50 per linear foot. The anticipated cost for this connection is approximately $550,000. End equipment in Raleigh is expected to cost $100,000 - with annual maintenance and operations costing approximately $10,000.

Raleigh-Durham Airport Connection

The Raleigh-Durham Airport connection is required for future use for a kiosk system, as well as a formal regional traveler information system. The capability to share video of traffic conditions and transit arrival and departure times with travelers in the airport is a valued commodity. Likewise, sharing plane arrival and departure times throughout the region can be beneficial. A bandwidth of approximately 16 Mbs is required.

NCDOT currently has fiber running along I-40 in the vicinity of the airport. It will require approximately three miles of additional conduit and fiber to install the necessary infrastructure. Conduit and fiber optic cable installed near the airport will cost approximately $30 per linear foot. The anticipated cost for this connection is approximately $500,000. It is assumed that, within the airport right-of-way, there already is conduit in place that has the capacity for additional fiber optic cable. If new construction is needed to connect the terminals, the air traffic control towers, and the airlines, significant additional costs can be incurred. End equipment in the airport is expected to cost $100,000 - with annual maintenance and operations costing approximately $10,000.

Chapel Hill Connection

The Town of Chapel Hill needs a relatively small connection with a bandwidth of approximately 10 Mbs to share data and video for special events, basketball games, and other events. The Chapel Hill connection will require approximately six miles of conduit and fiber optic cable. Approximately four of these six miles will be connected as part of the 15-501 freeway management system project. The remaining two miles will be constructed in mixed conditions, and will cost approximately $50 per linear foot for the installation of conduit and cable. The anticipated cost for this connection is $550,000. End equipment in Chapel Hill is expected to cost $100,000 - with annual maintenance and operations costing approximately $10,000.

Cary Connection

Like Chapel Hill, the Town of Cary, due to the growth of the region as a suburb of sorts for the RTP, needs a relatively small connection of approximately 10 Mbs bandwidth to share data and video for special events. The Cary connection will require approximately four miles of conduit and fiber optic cable. This conduit and cable will be installed in the next few years as part of the Cary signal system. The connection of the Town to the NCDOT fiber will require end equipment and splicing. End equipment in Cary is expected to cost $100,000 - with annual maintenance and operations costing approximately $10,000.

County Connections

The connections between the various agencies and the counties, as well as between the TRTMC and the counties do not require significant infrastructure. The information being passed between these agencies is typically data regarding vehicle location, railroad crossing status, and preemption for emergency vehicles. Where a connection does not already exist, a low bandwidth solution is sufficient. These links can be accomplished through a leased connection operating at 256Kbs. Either DSL, ISDN, or partial T-1 technology can be used. Each link will cost approximately $10,000 per year, with an initial setup charge of $2,000.

Statewide Link

The statewide link is necessary for numerous reasons, most notably to monitor traffic status in the Piedmont Triad Region and Metrolina regions, and for those regions to view traffic in the Triangle. Traffic monitoring and control is a local issue, with regional and statewide impacts. For this reason, transmitting basic data and video images to a statewide network does not require the same quality as for local information. Video images within the Triangle are planned to be transmitted at the television standard of between 3 and 6 Mbs, statewide video transmission is recommended to be limited to 384 Kbs.

The statewide link is recommended to be a leased network at this time. Several states are in the process of developing statewide fiber optic deployments from border to border along the major freeways, with assistance from private partners. In lieu of this occurring in North Carolina, a statewide leased network is sufficient to provide basic data and video transmission. It is recommended that a total three T-1 connections be provided from the Triangle Region to NCDOT headquarters in Raleigh. The cost to lease the bandwidth required to connect these two centers would be approximately $30,000 per year, in addition to a one-time setup and installation cost of approximately $20,000. Upon completion of the Raleigh signal system or the construction of the fiber network around Raleigh by NCDOT, this connection can be upgraded to a higher bandwidth, as necessary.

APPENDIX

Meetings

Summits

NIA Compliance

FHWA: Off-Model Air Quality Analysis – A Compendium of Practice – August 1999

Turbo Architecture Output

Triangle Region Sausage Diagram

Triangle Turbo Architecture Interconnect Diagram

Triangle Turbo Architecture Flow Diagram

Triangle Inventory to Market Package Comparison

Triangle Market Packages Report

Triangle Relevant Standards Activities

Triangle Stakeholders Report

Triangle Regional Architecture (Sample)

- Complete architecture is over 830 pages long and included in a separate appendix.